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(54) Title: CLEANING PROCESS AND COMPOSITION

## (57) Abstract

A process for removing contaminants from the surface of a substrate comprises contacting the substrate with a cleaning composition comprising at least one mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane, perfluorocycloalkyl-containing perfluoroalkane, or perfluorocycloalkylene-containing perfluoroalkane compound, the compound optionally containing additional catenated heteroatoms. The compounds exhibit good solvency properties while being environmentally acceptable.

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CLEANING PROCESS AND COMPOSITION

5           This application is a continuation-in-part of  
Application No. 08/573,416 filed December 15, 1995.

Field of the Invention

10          This invention relates to cleaning  
compositions comprising at least one partially-  
fluorinated ether compound and to processes for  
removing contaminants from substrate surfaces using  
such compositions. In another aspect, this invention  
relates to certain novel partially-fluorinated ether  
15         compounds. In yet another aspect, this invention  
relates to coating compositions comprising at least one  
partially-fluorinated ether compound and to processes  
for depositing coatings on substrate surfaces using  
such compositions.

20

Background of the Invention

25          Solvent cleaning applications where  
contaminated articles are immersed in (or washed with)  
solvent liquids and/or vapors are well-known.  
Applications involving one or more stages of immersion,  
rinsing, and/or drying are common. Solvents can be  
used at ambient temperature (often, accompanied by  
ultrasonic agitation) or at elevated temperatures up to  
the boiling point of the solvent.

30          A major concern in solvent cleaning is the  
tendency (especially where solvent is used at an

elevated temperature) for solvent vapor loss from the cleaning system into the atmosphere. Although care is generally exercised to minimize such losses (e.g., through good equipment design and vapor recovery systems), most practical cleaning applications result in some loss of solvent vapor into the atmosphere.

5 Solvent cleaning processes have traditionally utilized chlorinated solvents (e.g., chlorofluorocarbons such as 1,1,2-trichloro-1,2,2- systems), trifluoroethane and chlorocarbons such as 1,1,1-trichloroethane) alone or in admixture with one or more cosolvents such as aliphatic alcohols or other low molecular weight, polar compounds. Such solvents were initially believed to be environmentally-benign, but 10 have now been linked to ozone depletion. According to the Montreal Protocol and its attendant amendments, production and use of the solvents must be discontinued (see, e.g., P. S. Zurer, "Looming Ban on Production of CFCs, Halons Spurs Switch to Substitutes," Chemical & 15 Engineering News, page 12, November 15, 1993).

Thus, there has developed a need in the art for substitutes or replacements for the commonly-used cleaning solvents. Such substitutes should have a low ozone depletion potential, should have boiling ranges 20 suitable for a variety of solvent cleaning applications, and should have the ability to dissolve both hydrocarbon-based and fluorocarbon-based soils. Preferably, substitutes will also be low in toxicity, have no flash points (as measured by ASTM D3278-89), 25 have acceptable stability for use in cleaning

applications, and have short atmospheric lifetimes and low global warming potentials.

Partially-fluorinated ethers have been suggested as chlorofluorocarbon alternatives (see, 5 e.g., Yamashita et al., International Conference on CFC and BFC (Halons), Shanghai, China, August 7-10, 1994, pages 55-58).

European Patent Publication No. 0 450 855 A2 (Imperial Chemical Industries PLC) describes the use of 10 low molecular weight, fluorine-containing ethers of boiling point 20-120°C in solvent cleaning applications.

International Patent Publication No. WO 93/11280 (Allied-Signal, Inc.) discloses a non-aqueous cleaning process which utilizes a fluorocarbon-based rinsing solvent. 15

U.S. Patent No. 5,275,669 (Van Der Puy et al.) describes hydrofluorocarbon solvents useful for dissolving contaminants or removing contaminants from the surface of a substrate. The solvents have 4 to 7 20 carbon atoms and have a portion which is fluorocarbon, the remaining portion being hydrocarbon.

U.S. Patent No. 3,453,333 (Litt et al.) discloses fluorinated ethers containing at least one halogen substituent other than fluorine and states that 25 those ethers which are liquid can be used as solvents for high molecular weight resinous perhalogenated compounds such as solid polychlorotrifluoroethylene resins.

French Patent Publication No. 2,287,432 (Societe Nationale des Poudres et Explosifs) describes 30 new partially-fluorinated ethers and a process for

their preparation. The compounds are said to be useful as hypnotic and anesthetic agents; as monomers for preparing heat-stable, fire-resistant, or self-lubricant polymers; and in phyto-sanitary and phyto-pharmaceutical fields.

5 German Patent Publication No. 1,294,949 (Farbwerke Hoechst AG) describes a technique for the production of perfluoroalkyl-alkyl ethers, said to be useful as narcotics and as intermediates for the 10 preparation of narcotics and polymers.

#### Summary of the Invention

In one aspect, this invention provides a process for removing contaminants (e.g., hydrocarbons, 15 fluorocarbons, or even water) from the surface of a substrate (e.g., metal, glass, ceramic, plastic, or fabric). The process comprises contacting the substrate with (or exposing the substrate to) a liquid- and/or vapor-phase cleaning composition comprising at 20 least one mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane, perfluorocycloalkyl-containing perfluoroalkane, or perfluorocycloalkylene-containing perfluoroalkane compound. The compound can optionally contain 25 additional catenary (i.e., in-chain) heteroatoms (e.g., oxygen or nitrogen) and preferably has a boiling point in the range of from about 25°C to about 200°C.

The alkoxy-substituted compounds used in the process of the invention exhibit unexpectedly high 30 stabilities in the presence of acids, bases, and oxidizing agents. In addition, in spite of their

fluorine content, the compounds are surprisingly good solvents for hydrocarbons (as well as fluorocarbons). The compounds are low in toxicity and flammability, have ozone depletion potentials of zero, and have short 5 atmospheric lifetimes and low global warming potentials relative to chlorofluorocarbons and many chlorofluorocarbon substitutes. Since the compounds exhibit good solvency properties while being environmentally acceptable, they satisfy the need in 10 the art for substitutes or replacements for the commonly-used cleaning solvents which have been linked to the destruction of the earth's ozone layer.

In other aspects, this invention also provides certain novel mono-, di-, and trialkoxy- 15 substituted perfluorocompounds; a cleaning composition; a coating composition; and a process for depositing coatings (e.g., coatings of lubricant) on substrate surfaces.

20 Detailed Description of the Invention

Compounds which can be utilized in the processes of the invention are mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane, perfluorocycloalkyl-containing 25 perfluoroalkane, and perfluorocycloalkylene-containing perfluoroalkane compounds. The compounds include those which contain additional catenary heteroatoms (as well as those which do not) and can be utilized alone, in combination with one another, or in combination with 30 other common cleaning solvents (e.g., alcohols, ethers, alkanes, alkenes, perfluorocarbons, perfluorinated

tertiary amines, perfluoroethers, cycloalkanes, esters, ketones, aromatics, siloxanes, hydrochlorocarbons, hydrochlorofluorocarbons, and hydrofluorocarbons). The compounds can be solids or liquids under ambient 5 conditions of temperature and pressure, but are generally utilized for cleaning in either the liquid or the vapor state (or both). Thus, normally solid compounds can be utilized after transformation to liquid and/or vapor through melting, sublimation, or 10 dissolution in liquid co-solvent.

A class of useful alkoxy-substituted perfluorocompounds is that which can be represented by the following general formula (I):

15 
$$R_f - (O - R_h)_x \quad (I)$$
 wherein x is an integer of 1 to 3; when x is 1,  $R_f$  is selected from the group consisting of linear or branched perfluoroalkyl groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl-containing 20 perfluoroalkyl groups having from 5 to about 15 carbon atoms, and perfluorocycloalkyl groups having from 3 to about 12 carbon atoms; when x is 2,  $R_f$  is selected from the group consisting of linear or branched perfluoroalkanediyl groups or perfluoroalkylidene 25 groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-containing perfluoroalkanediyl or perfluoroalkylidene groups having from 6 to about 15 carbon atoms, and perfluorocycloalkanediyl groups or 30 perfluorocycloalkylidene groups having from 3 to about 12 carbon atoms; when x is 3,  $R_f$  is selected from the

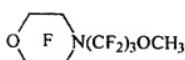
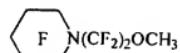
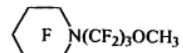
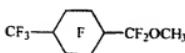
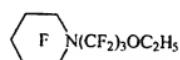
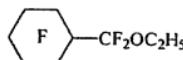
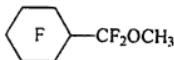
group consisting of linear or branched perfluoroalkanetriyl groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-containing perfluoroalkanetriyl groups having from 6 to about 15 carbon atoms, and perfluorocycloalkanetriyl groups having from 3 to about 12 carbon atoms; each  $R_h$  is independently selected from the group consisting of linear or branched alkyl groups having from 1 to about 8 carbon atoms, cycloalkyl- containing alkyl groups having from 4 to about 8 carbon atoms, and cycloalkyl groups having from 3 to about 8 carbon atoms; wherein either or both of the groups  $R_f$  and  $R_h$  can contain (optionally contain) one or more catenary heteroatoms; and wherein the sum of the number of carbon atoms in  $R_f$  and the number of carbon atoms in  $R_h$  is greater than or equal to 4. The perfluorocycloalkyl and perfluorocycloalkylene groups contained within the perfluoroalkyl, perfluoroalkanediyl, perfluoroalkylidene and perfluoroalkanetriyl groups can optionally (and independently) be substituted with, e.g., one or more perfluoroalkyl groups having from 1 to about 4 carbon atoms.

Preferably,  $x$  is 1;  $R_f$  is as defined above;  $R_h$  is an alkyl group having from 1 to about 6 carbon atoms;  $R_f$  but not  $R_h$  can contain one or more catenary heteroatoms; and the sum of the number of carbon atoms in  $R_f$  and the number of carbon atoms in  $R_h$  is greater than or equal to 4. Most preferably,  $x$  is 1;  $R_f$  is selected from the group consisting of linear or branched perfluoroalkyl groups having from 3 to about 6

carbon atoms, perfluorocycloalkyl-containing perfluoroalkyl or perfluoroalkylidene groups having from 5 to about 8 carbon atoms, and perfluorocycloalkyl groups having from 5 to about 6 carbon atoms;  $R_h$  is an alkyl group having from 1 to about 3 carbon atoms;  $R_f$  but not  $R_h$  can contain one or more catenary heteroatoms; and the sum of the number of carbon atoms in  $R_f$  and the number of carbon atoms in  $R_h$  is greater than or equal to 4. The perfluorocycloalkyl and perfluorocycloalkylene groups contained within the perfluoroalkyl, perfluoroalkanediyl, perfluoroalkylidene and perfluoroalkanetriyl groups can optionally (and independently) be substituted with, e.g., one or more perfluoromethyl groups. These compounds are preferred due to their ease of preparation and their performance characteristics.

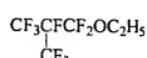
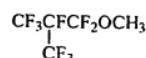
Representative examples of alkoxy-substituted perfluorocompounds suitable for use in the processes of the invention include the following compounds:

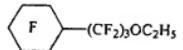
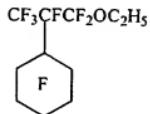
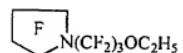
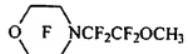
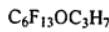
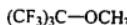
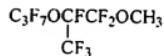
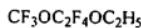
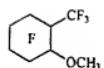
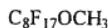
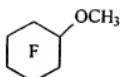
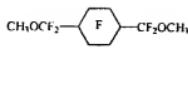
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n— $C_4F_9OCH_3$

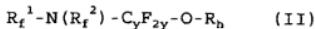
n— $C_4F_9OC_2H_5$





and 1,1-dimethoxyperfluorocyclohexane, where cyclic structures having an interior "F" are perfluorinated.

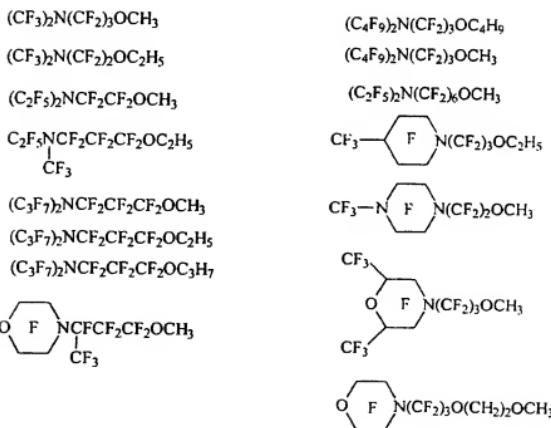
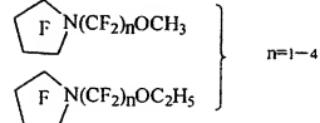
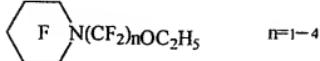
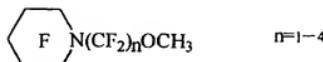
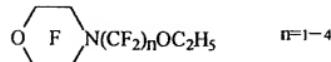
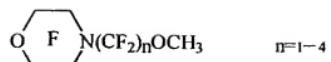
A novel subclass of the alkoxy-substituted perfluorocompounds is that which can be represented by 5 the following general formula (II):



wherein  $R_f^1$  and  $R_f^2$  are both substituted or unsubstituted 5 perfluoroalkyl groups having from 1 to about 6 carbon atoms or are both substituted or unsubstituted perfluoroalkylene groups having from 2 to about 4 carbon atoms, the perfluoroalkylene groups being bonded to one another to form a ring;  $y$  is an integer of 1 to 10 about 8;  $C_y F_{2y}$  can be linear or branched; and  $R_h$  is selected from the group consisting of linear or branched alkyl groups having from 1 to about 8 carbon atoms, cycloalkyl-containing alkyl groups having from 4 to about 8 carbon atoms, and cycloalkyl groups having 15 from 3 to about 8 carbon atoms; wherein the groups  $R_f^1$ ,  $R_f^2$ , and  $R_h$  can optionally (and independently) contain one or more catenary heteroatoms.

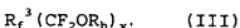
Preferably, the perfluoroalkyl groups have from 1 to about 3 carbon atoms, the perfluoroalkylene 20 groups have from 2 to about 3 carbon atoms;  $y$  is an integer of 1 to about 3;  $R_h$  is selected from the group consisting of linear or branched alkyl groups having from 1 to about 6 carbon atoms; and  $R_f^1$  and  $R_f^2$  but not  $R_h$  can independently contain one or more catenary 25 heteroatoms. These compounds are preferred due to their ease of preparation and their performance characteristics.

Representative examples of novel compounds according to Formula II above include the following 30 compounds:



A second novel subclass of the alkoxy-substituted perfluorocompounds is that which can be represented by the following general formula (III):

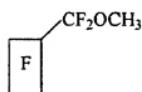
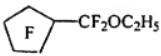
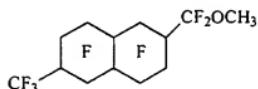
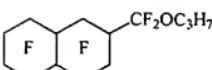
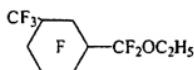
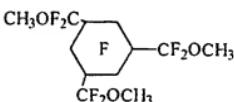
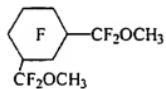
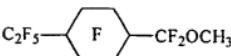
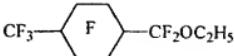
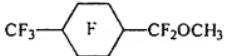
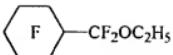
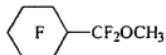
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wherein  $R_f^3$  is a substituted or unsubstituted perfluorocycloalkyl, perfluorocycloalkanediyl, or perfluorocycloalkanetriyl group having from 3 to about 10 carbon atoms; each  $R_h$  is independently selected from the group consisting of linear or branched alkyl groups having from 1 to about 8 carbon atoms, cycloalkyl-containing alkyl groups having from 4 to about 8 carbon atoms, and cycloalkyl groups having from 3 to about 8 carbon atoms; and  $x'$  is an integer of 1 to 3; wherein either or both of the groups  $R_f^3$  and  $R_h$  can contain (optionally contain) one or more catenary heteroatoms.

Preferably,  $R_f^3$  has from 5 to about 6 carbon atoms; each  $R_h$  is independently selected from the group consisting of linear or branched alkyl groups having from 1 to about 6 carbon atoms;  $x'$  is an integer of 1 or 2; and  $R_f^3$  but not  $R_h$  can contain one or more catenary heteroatoms. These compounds are preferred due to their ease of preparation and their performance characteristics.

Representative examples of novel compounds according to Formula III above include the following compounds:



5

The alkoxy-substituted perfluorocompounds suitable for use in the process of the invention can be prepared by alkylation of perfluorinated alkoxides prepared by the reaction of the corresponding perfluorinated acyl fluoride or perfluorinated ketone

with an anhydrous alkali metal fluoride (e.g., potassium fluoride or cesium fluoride) or anhydrous silver fluoride in an anhydrous polar, aprotic solvent. (See, e.g., the preparative methods described in French 5 Patent Publication No. 2,287,432 and German Patent Publication No. 1,294,949, *supra*.) Alternatively, a fluorinated tertiary alcohol can be allowed to react with a base, e.g., potassium hydroxide or sodium hydride, to produce a perfluorinated tertiary alkoxide 10 which can then be alkylated by reaction with alkylating agent.

Suitable alkylating agents for use in the preparation include dialkyl sulfates (e.g., dimethyl sulfate), alkyl halides (e.g., methyl iodide), alkyl 15 p-toluenesulfonates (e.g., methyl p-toluenesulfonate), alkyl perfluoroalkanesulfonates (e.g., methyl perfluoromethanesulfonate), and the like. Suitable polar, aprotic solvents include acyclic ethers such as diethyl ether, ethylene glycol dimethyl ether, and 20 diethylene glycol dimethyl ether; carboxylic acid esters such as methyl formate, ethyl formate, methyl acetate, diethyl carbonate, propylene carbonate, and ethylene carbonate; alkyl nitriles such as acetonitrile; alkyl amides such as 25 N,N-dimethylformamide, N,N-diethylformamide, and N-methylpyrrolidone; alkyl sulfoxides such as dimethyl sulfoxide; alkyl sulfones such as dimethylsulfone, tetramethylene sulfone, and other sulfolanes; oxazolidones such as N-methyl-2-oxazolidone; and 30 mixtures thereof.

Perfluorinated acyl fluorides (for use in

preparing the alkoxy-substituted perfluorocompounds) can be prepared by electrochemical fluorination (ECF) of the corresponding hydrocarbon carboxylic acid (or a derivative thereof), using either anhydrous hydrogen 5 fluoride (Simons ECF) or KF.2HF (Phillips ECF) as the electrolyte. Perfluorinated acyl fluorides and perfluorinated ketones can also be prepared by dissociation of perfluorinated carboxylic acid esters (which can be prepared from the corresponding 10 hydrocarbon or partially-fluorinated carboxylic acid esters by direct fluorination with fluorine gas). Dissociation can be achieved by contacting the perfluorinated ester with a source of fluoride ion under reacting conditions (see the method described in 15 U.S. Patent No. 3,900,372 (Childs), the description of which is incorporated herein by reference) or by combining the ester with at least one initiating reagent selected from the group consisting of gaseous, non-hydroxylic nucleophiles; liquid, non-hydroxylic 20 nucleophiles; and mixtures of at least one non-hydroxylic nucleophile (gaseous, liquid, or solid) and at least one solvent which is inert to acylating agents.

Initiating reagents which can be employed in 25 the dissociation are those gaseous or liquid, non-hydroxylic nucleophiles and mixtures of gaseous, liquid, or solid, non-hydroxylic nucleophile(s) and solvent (hereinafter termed "solvent mixtures") which are capable of nucleophilic reaction with 30 perfluorinated esters. The presence of small amounts of hydroxylic nucleophiles can be tolerated. Suitable

gaseous or liquid, non-hydroxylic nucleophiles include dialkylamines, trialkylamines, carboxamides, alkyl sulfoxides, amine oxides, oxazolidones, pyridines, and the like, and mixtures thereof. Suitable non-  
5 hydroxylic nucleophiles for use in solvent mixtures include such gaseous or liquid, non-hydroxylic nucleophiles, as well as solid, non-hydroxylic nucleophiles, e.g., fluoride, cyanide, cyanate, iodide, chloride, bromide, acetate, mercaptide, alkoxide,  
10 thiocyanate, azide, trimethylsilyl difluoride, bisulfite, and bifluoride anions, which can be utilized in the form of alkali metal, ammonium, alkyl-substituted ammonium (mono-, di-, tri-, or tetra-substituted), or quaternary phosphonium salts, and  
15 mixtures thereof. Such salts are in general commercially available but, if desired, can be prepared by known methods, e.g., those described by M. C. Sneed and R. C. Brasted in Comprehensive Inorganic Chemistry, Volume Six (The Alkali Metals), pages 61-64, D. Van  
20 Nostrand Company, Inc., New York (1957), and by H. Kobler et al. in *Justus Liebigs Ann. Chem.* 1978, 1937. 1,4-diazabicyclo[2.2.2]octane and the like are also suitable solid nucleophiles.

The cleaning process of the invention can be  
25 carried out by contacting a contaminated substrate with a cleaning composition comprising at least one of the above-described alkoxy-substituted perfluorocompounds. The perfluorocompounds can be utilized alone or in admixture with each other or with other commonly-used  
30 cleaning solvents, e.g., alcohols, ethers, alkanes, alkenes, perfluorocarbons, perfluorinated tertiary

amines, perfluoroethers, cycloalkanes, esters, ketones, aromatics, siloxanes, hydrochlorocarbons, hydrochlorofluorocarbons, and hydrofluorocarbons. Such co-solvents can be chosen to modify or enhance the 5 solvency properties of a cleaning composition for a particular use and can be utilized in ratios (of co-solvent to perfluorocompound(s)) such that the resulting composition has no flash point. Preferably, the perfluorocompound(s) used in the composition have 10 boiling points in the range of from about 25°C to about 200°C, more preferably from about 25°C to about 125°C.

To remove soils from fiber and textile substrates, the cleaning process of the invention can be carried out by contacting the fiber or textile with 15 a cleaning composition comprising an alkoxy-substituted perfluoroalkane at ambient or elevated temperatures. The soiled textile can be agitated to promote the dissolving, dispersing or displacing of soil using any conventional agitation means including shaking, 20 stirring and ultrasonic agitation. When the textile is sufficiently cleaned, the cleaning composition may be removed (e.g. by decantation), the textile optionally rinsed using an alkoxy-substituted perfluoroalkane or any conventional dry-cleaning solvent to ensure soil 25 removal and prevent redeposition, and the textile can be dried, for example, by air-drying with or without added heat.

Optionally and preferably, the cleaning composition further comprises a surfactant. Suitable 30 surfactants include those surfactants that are sufficiently soluble in the alkoxy-substituted

perfluoroalkane, and which promote soil removal by dissolving, dispersing or displacing the soil. One useful class of surfactants are those nonionic surfactants that have a hydrophilic-lipophilic balance 5 (HLB) value of less than about 14. Examples include ethoxylated alcohols, ethoxylated alkylphenols, ethoxylated fatty acids, alkylaryl sulfonates, glycerol esters, ethoxylated fluoroalcohols, and fluorinated sulfonamides. Mixtures of surfactants having 10 complementary properties may be used in which one surfactant is added to the cleaning composition to promote oily soil removal and another added to promote water-soluble soil removal.

The surfactant, if used, can be added in an amount 15 sufficient to promote soil removal. Typically, surfactant is added in amounts from about 0.1 to 5.0 wt.%, preferably in amounts from about 0.2 to 2.0 wt.% of the cleaning composition.

The cleaning composition can be used in 20 either the gaseous or the liquid state (or both), and any of the known techniques for "contacting" a substrate can be utilized. For example, a liquid cleaning composition can be sprayed or brushed onto the substrate, a gaseous cleaning composition can be blown 25 across the substrate, or the substrate can be immersed in either a gaseous or a liquid composition. Elevated temperatures, ultrasonic energy, and/or agitation can be used to facilitate the cleaning. Various different solvent cleaning techniques are described by B. N. 30 Ellis in Cleaning and Contamination of Electronics

Components and Assemblies, Electrochemical Publications Limited, Ayr, Scotland, pages 182-94 (1986).

Both organic and inorganic substrates can be cleaned by the process of the invention.

5 Representative examples of the substrates include metals; ceramics; glass; polycarbonate; polystyrene; acrylonitrile-butadiene-styrene copolymer; synthetic non-woven materials; natural fibers (and fabrics derived therefrom) such as cotton, silk, fur, suede, 10 leather, linen, and wool; synthetic fibers (and fabrics) such as polyester, rayon, acrylics, nylon, and blends thereof; fabrics comprising a blend of natural and synthetic fibers; and composites of the foregoing materials. The process is especially useful in the 15 precision cleaning of electronic components (e.g., circuit boards), optical or magnetic media, and medical devices.

The cleaning process of the invention can be used to dissolve or remove most contaminants from the 20 surface of a substrate. For example, materials such as light hydrocarbon contaminants; higher molecular weight hydrocarbon contaminants such as mineral oils and greases; fluorocarbon contaminants such as perfluoropolyethers, bromotrifluoroethylene oligomers 25 (gyroscope fluids), and chlorotrifluoroethylene oligomers (hydraulic fluids, lubricants); silicone oils and greases; solder fluxes; particulates; and other contaminants encountered in precision, electronic, metal, and medical device cleaning can be removed. 30 The process is particularly useful for the removal of hydrocarbon contaminants (especially, light hydrocarbon

oils), fluorocarbon contaminants, particulates, and water (as described in the next paragraph).

To displace or remove water from substrate surfaces, the cleaning process of the invention can be 5 carried out as described in U.S. Patent No. 5,125,978 (Flynn et al.) by contacting the surface of an article with a liquid cleaning composition which preferably contains a non-ionic fluoroaliphatic surface active agent. The wet article is immersed in the liquid 10 composition and agitated therein, the displaced water is separated from the liquid composition, and the resulting water-free article is removed from the liquid composition. Further description of the process and the articles which can be treated are found in said 15 U.S. Patent No. 5,125,978, which description is incorporated herein by reference. The process can also be carried out as described in U.S. Patent No. 3,903,012 (Brandreth), the description of which is also incorporated herein.

20 This invention also provides a cleaning composition comprising (a) a major amount (preferably, at least about 60 percent of the composition by weight) of at least one mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane, 25 perfluorocycloalkyl-containing perfluoroalkane, or perfluorocycloalkylene-containing perfluoroalkane compound, the compound optionally containing additional catenary heteroatoms; and (b) a minor amount of at least one co-solvent selected from the group consisting 30 of alcohols, ethers, alkanes, alkenes, perfluorocarbons, perfluorinated tertiary amines,

perfluoroethers, cycloalkanes, esters, ketones, aromatics, siloxanes, hydrochlorocarbons, hydrochlorofluorocarbons, and hydrofluorocarbons.

Preferably, the co-solvent is selected from the group 5 consisting of alcohols, alkanes, alkenes, cycloalkanes, esters, aromatics, hydrochlorocarbons, and hydrofluorocarbons.

Representative examples of co-solvents which can be used in the cleaning composition include

- 10 methanol, ethanol, isopropanol, t-butyl alcohol, methyl t-butyl ether, methyl t-amyl ether, 1,2-dimethoxyethane, cyclohexane, 2,2,4-trimethylpentane, n-decane, terpenes (e.g., a-pinene, camphene, and limonene), trans-1,2-dichloroethylene,
- 15 methylcyclopentane, decalin, methyl decanoate, t-butyl acetate, ethyl acetate, diethyl phthalate, 2-butanone, methyl isobutyl ketone, naphthalene, toluene, p-chlorobenzotrifluoride, trifluorotoluene, hexamethyl disiloxane, octamethyl trisiloxane, perfluorohexane,
- 20 perfluoroheptane, perfluoroctane, perfluorotributylamine, perfluoro-N-methyl morpholine, perfluoro-2-butyl oxacyclopentane, methylene chloride, chlorocyclohexane, 1-chlorobutane, 1,1-dichloro-1-fluoroethane, 1,1,1-trifluoro-2,2-dichloroethane,
- 25 1,1,1,2,2-pentafluoro-3,3-dichloropropane, 1,1,2,2,3-pentafluoro-1,3-dichloropropane, 2,3-dihydroperfluoropentane, 1,1,1,2,2,4-hexafluorobutane, 1-trifluoromethyl-1,2,2-trifluorocyclobutane, 3-methyl-1,1,2,2-tetrafluorocyclobutane, and 1-
- 30 hydropentadecafluoroheptane.

The above-described alkoxy-substituted perfluorocompounds can be useful not only in cleaning but also in coating deposition, where the perfluorocompound functions as a carrier for a coating

5 material to enable deposition of the material on the surface of a substrate. The invention thus also provides a coating composition and a process for depositing a coating on a substrate surface using the composition. The process comprises the step of

10 applying to at least a portion of at least one surface of a substrate a coating of a liquid coating composition comprising (a) a solvent composition comprising at least one mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane,

15 perfluorocycloalkyl-containing perfluoroalkane, or perfluorocycloalkylene-containing perfluoroalkane compound, the compound optionally containing additional catenary heteroatoms; and (b) at least one coating material which is soluble or dispersible in the solvent

20 composition. The solvent composition can further comprise one or more co-dispersants or co-solvents (as defined *supra*, preferably those having boiling points below about 125°C) and/or one or more additives (e.g., surfactants, coloring agents, stabilizers, anti-

25 oxidants, flame retardants, and the like). Preferably, the process further comprises the step of removing the solvent composition from the coating by, e.g., allowing evaporation (which can be aided by the application of, e.g., heat or vacuum).

30 Coating materials which can be deposited by the process include pigments, lubricants, stabilizers,

adhesives, anti-oxidants, dyes, polymers, pharmaceuticals, release agents, inorganic oxides, and the like, and combinations thereof. Preferred materials include perfluoropolyether, hydrocarbon, and 5 silicone lubricants; amorphous copolymers of tetrafluoroethylene; polytetrafluoroethylene; and combinations thereof. Representative examples of materials suitable for use in the process include titanium dioxide, iron oxides, magnesium oxide, 10 perfluoropolyethers, polysiloxanes, stearic acid, acrylic adhesives, polytetrafluoroethylene, amorphous copolymers of tetrafluoroethylene, and combinations thereof. Any of the substrates described above (for cleaning applications) can be coated via the process of 15 the invention. The process can be particularly useful for coating magnetic hard disks or electrical connectors with perfluoropolyether lubricants or medical devices with silicone lubricants.

To form a coating composition, the components 20 of the composition (i.e., the alkoxy-substituted perfluorocompound(s), the coating material(s), and any co-dispersant(s) or co-solvent(s) utilized) can be combined by any conventional mixing technique used for dissolving, dispersing, or emulsifying coating 25 materials, e.g., by mechanical agitation, ultrasonic agitation, manual agitation, and the like. The solvent composition and the coating material(s) can be combined in any ratio depending upon the desired thickness of the coating, but the coating material(s) preferably 30 constitute from about 0.1 to about 10 weight percent of the coating composition for most coating applications.

The deposition process of the invention can be carried out by applying the coating composition to a substrate by any conventional technique. For example, the composition can be brushed or sprayed (e.g., as an aerosol) onto the substrate, or the substrate can be spin-coated. Preferably, the substrate is coated by immersion in the composition. Immersion can be carried out at any suitable temperature and can be maintained for any convenient length of time. If the substrate is 5 a tubing, such as a catheter, and it is desired to ensure that the composition coats the lumen wall, it may be advantageous to draw the composition into the lumen by the application of reduced pressure. 10

After a coating is applied to a substrate, 15 the solvent composition can be removed from the coating by evaporation. If desired, the rate of evaporation can be accelerated by application of reduced pressure or mild heat. The coating can be of any convenient thickness, and, in practice, the thickness will be 20 determined by such factors as the viscosity of the coating material, the temperature at which the coating is applied, and the rate of withdrawal (if immersion is utilized).

Objects and advantages of this invention are 25 further illustrated by the following examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this invention.

**Examples**

The environmental impact of the alkoxy-substituted perfluorocompounds used in the processes and compositions of the invention was assessed by 5 determination of the atmospheric lifetime and the global warming potential (GWP) of certain compounds, as described below:

**Atmospheric Lifetime**

10 The atmospheric lifetime ( $t_{sample}$ ) of various sample compounds was calculated by the technique described in Y. Tang, Atmospheric Fate of Various Fluorocarbons, M.S. Thesis, Massachusetts Institute of Technology (1993). According to this technique, an ultraviolet 15 (UV) gas cell was charged with a sample compound, a reference compound (either  $CH_4$  or  $CH_3Cl$ ), ozone, and water vapor. Hydroxyl radicals were then generated by photolytic decomposition of the ozone in the presence of the water vapor and an inert buffer gas, i.e., 20 helium. As the sample compounds and reference compounds reacted with the hydroxyl radicals in the gas phase, their concentrations were measured by Fourier transform infrared spectroscopy (FTIR). The rate constant for reaction of the sample compound ( $k_{sample}$ ) 25 with hydroxyl radical was measured relative to the rate constant for a reference compound ( $k_{ref}$ ), and the atmospheric lifetime was then calculated using the following formula (where  $t_{CH_4}$  and  $k_{CH_4}$  are known values):

$$\tau_{\text{sample}} = \frac{\tau_{\text{CH}_4}}{\left( \frac{k_{\text{sample}}}{k_{\text{ref}}} \right) \left( \frac{k_{\text{ref}}}{k_{\text{CH}_4}} \right)}$$

5

The rate constant for each sample compound was measured (using CH<sub>4</sub> as the reference compound and again using CH<sub>3</sub>Cl) at 298K, and the atmospheric lifetime values were calculated and then averaged. The results are shown in 10 Table A under the heading "Atmospheric Lifetime." For comparative purposes, the atmospheric lifetime for several hydrofluorocarbons is also shown in Table A.

Atmospheric lifetime was also estimated from a correlation developed between the highest occupied 15 molecular orbital (HOMO) energy and the known atmospheric lifetimes of hydrofluorocarbons and hydrofluorocarbon ethers, in a manner similar to that described by Cooper et al. in *Atmos. Environ.* 26A, 1, 1331 (1992). The correlation differed from that found 20 in Cooper et al. in the following respects: the correlation was developed using a larger data set; lifetimes for the correlations were determined by relative hydroxyl reactivity of the sample to CH<sub>3</sub>CCl<sub>3</sub> at 277K, as described by Zhang et al. in *J. Phys. Chem.* 25 98(16), 4312 (1994); HOMO energy was calculated using MOPAC/PM3, a semi-empirical molecular orbital package; and the number of hydrogen atoms present in the sample was included in the correlation. The results are reported in Table A under the heading "Estimated 30 Atmospheric Lifetime."

Global Warming Potential

Global warming potential (GWP) was determined for the various sample compounds using the above-described calculated values for atmospheric lifetime 5 and experimentally determined infrared absorbance data integrated over the spectral region of interest, typically 500 to 2500 cm<sup>-1</sup>. The calculations were based on the definition of GWP set forth by the Intergovernmental Panel in Climate Change in Climate 10 Change: The IPCC Scientific Assessment, Cambridge University Press (1990). According to the Panel, GWP is the integrated potential warming due to the release of 1 kilogram of sample compound relative to the warming due to 1 kilogram of CO<sub>2</sub> over a specified 15 integration time horizon (ITH) using the following equation:

$$20 \quad GWP_{sample} = \frac{\int_0^{\infty} \Delta T_{sample} e^{-t/\tau_a} dt}{\int_0^{\infty} \Delta T_{CO_2} C_{CO_2} dt}$$

where ΔT is the calculated change in temperature at the earth's surface due to the presence of a particular 25 compound in the atmosphere [calculated using a spreadsheet model (using parameters described by Fisher et al. in *Nature* 344, 513 (1990)) derived from Atmospheric and Environmental Research, Inc.'s more complete one-dimensional radiative-convective model 30 (described by Wang et al. in *J. Atmos. Sci.* 38, 1167 (1981) and *J. Geophys. Res.* 90, 12971 (1985))], C is the

atmospheric concentration of the compound,  $t$  is the atmospheric lifetime of the compound (the calculated value described above), and  $x$  designates the compound of interest. Upon integration, the formula is as follows:

where  $A_1 = 0.30036$ ,  $A_2 = 0.34278$ ,  $A_3 = 0.35686$ ,  $\tau_1 = 6.993$ ,  $\tau_2 = 71.108$ , and  $\tau_3 = 815.73$  in the Siegenthaler

$$GWP_{sample} = \frac{\Delta T_e C_o \tau_x [1 - e^{-\pi H/\tau_x}]}{\Delta T_e C_o (1.3 \times 10^{-10}) [A_1 \tau_1 (1 - e^{-\pi H/\tau_1}) + A_2 \tau_2 (1 - e^{-\pi H/\tau_2}) + A_3 \tau_3 (1 - e^{-\pi H/\tau_3})]}$$

(1983) coupled ocean-atmosphere CO<sub>2</sub> model. The results of the calculations are shown in Table A below.

10

Table A

Compound	Estimated Atmospheric Lifetime (years)	Atmospheric Lifetime (years)	Global Warming Potential (100 year ITH)
CF <sub>3</sub> -CH <sub>3</sub>	62.2		
CF <sub>3</sub> -O-CH <sub>3</sub>	1.6		
C <sub>2</sub> F <sub>5</sub> -CH <sub>3</sub>	12.6		
C <sub>2</sub> F <sub>5</sub> -O-CH <sub>3</sub>	1.6		
C <sub>3</sub> F <sub>7</sub> -CH <sub>3</sub>	9.6		
C <sub>3</sub> F <sub>7</sub> -O-CH <sub>3</sub>	1.9		
C <sub>4</sub> F <sub>9</sub> -CH <sub>3</sub>	7.0		
C <sub>4</sub> F <sub>9</sub> -O-CH <sub>3</sub>	1.9	5.5	330
C <sub>4</sub> F <sub>9</sub> -C <sub>2</sub> H <sub>5</sub>	2.0		
C <sub>4</sub> F <sub>9</sub> -O-C <sub>2</sub> H <sub>5</sub>	0.5	1.2	70
C <sub>5</sub> F <sub>11</sub> OCH <sub>3</sub>	4.3		
CF <sub>3</sub> CF(OCH <sub>3</sub> )CF(CF <sub>3</sub> ) <sub>2</sub>	4-5		
C <sub>5</sub> F <sub>11</sub> OCH <sub>2</sub> H <sub>5</sub>	~1		
C-C <sub>6</sub> F <sub>11</sub> -CH <sub>3</sub>	13.7		

Compound	Estimated Atmospheric Lifetime (years)	Atmospheric Lifetime (years)	Global Warming Potential (100 year ITH)
C-C <sub>6</sub> F <sub>11</sub> -O-CH <sub>3</sub>	1.8	3.8	170
C <sub>2</sub> F <sub>5</sub> CF(OCH <sub>3</sub> )CF(CF <sub>3</sub> ) <sub>2</sub>	4-5		
CF <sub>3</sub> CFHCFHCF <sub>2</sub> CF <sub>3</sub>	23*		1000

\* A. M. Schmoltner et al., J. Phys. Chem. 97, 8976 (1993)

5 As can be seen in Table A, each of the various alkoxy-substituted perfluorocompounds unexpectedly has a lower atmospheric lifetime than the corresponding hydrofluorocarbon, i.e., the hydrofluorocarbon having the same carbon number. The alkoxy-substituted  
10 perfluorocompounds are thus more environmentally acceptable than the hydrofluorocarbons (which have previously been proposed as chlorofluorocarbon replacements).

15 The chemical stability of the alkoxy-substituted perfluorocompounds used in the processes and compositions of the invention was also evaluated to determine their suitability for use in cleaning and coating applications. In these tests, a compound was contacted with a chemical agent such as aqueous sodium  
20 acetate, aqueous KOH, concentrated sulfuric acid, or potassium permanganate in acetone to determine the stability of the compound to base, acid, or oxidant, as described below:

Stability in the Presence of Base

To assess hydrolytic stability, a ten gram sample of alkoxy-substituted perfluorocompound was combined with 10 g of 0.1M NaOAc and sealed in a 5 2.54 cm (internal diameter) by 9.84 cm Monel™ 400 alloy (66% nickel, 31.5% copper, and 1.2% iron and several minor components) tube (available from Paar Instrument Co. of Moline, Illinois as Part Number 4713cm). The tube was heated at 110°C in a forced air 10 convection oven for 16 hours. After cooling to room temperature, a 1 mL sample of the tube contents was diluted with 1 mL of total ionic strength adjustment buffer (TISAB, available from Orion Research, Inc., a mixture of 1,2-cyclohexylene dinitrilotetraacetic acid, 15 deionized water, sodium acetate, sodium chloride, and acetic acid). The concentration of fluoride ion (resulting from any reaction of the perfluorocompound with the aqueous NaOAc) was measured using an Orion Model 720A Coulombmeter with a F<sup>-</sup> specific electrode 20 which had been previously calibrated using 0.5 and 500 ppm F<sup>-</sup> solutions. Based on the measured fluoride ion concentration, the rate at which HF had been generated by reaction of the aqueous NaOAc with the perfluorocompound was calculated. The results are 25 shown below in Table B and indicate that the alkoxy-substituted perfluorocompounds are much more stable to base than is the comparative compound.

Table B

	C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>	C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub>	c-C <sub>6</sub> F <sub>11</sub> OCH <sub>3</sub>	CF <sub>3</sub> CFHCFHCF <sub>2</sub> CF <sub>3</sub>
HF Generation Rate ( $\mu$ g/g/hr)	0.67	0.22	0.33	42.9

To assess hydrolytic stability under more severely basic conditions, C<sub>4</sub>F<sub>9</sub>OCH<sub>3</sub> (125 g of 99.8% 5 purity, 0.5 mole) was combined with potassium hydroxide (29.4 g, 0.45 mole, dissolved in 26.1 g water) in a 250 mL flask equipped with an overhead stirrer, a condenser, and a thermometer, and the resulting solution was refluxed at 58°C for 19 hours. Water 10 (50 mL) was added to the solution after refluxing, and the resulting product was distilled. The lower fluorochemical phase of the resulting distillate was separated from the upper phase and was washed with water (100 mL) to yield 121.3 g of recovered C<sub>4</sub>F<sub>9</sub>OCH<sub>3</sub>, 15 which was identical in purity and composition to the starting material (as shown by gas chromatography). The aqueous base solution remaining in the reaction flask was titrated with standard 1.0 N HCl to reveal that none of the KOH originally charged had been 20 consumed, indicating that the perfluorocompound was stable in the presence of the base.

Stability in the Presence of Acid

To assess hydrolytic stability under acidic 25 conditions, C<sub>4</sub>F<sub>9</sub>OCH<sub>3</sub> (15 g, 0.06 mole) was combined with sulfuric acid (10 g of 96% by weight, 0.097 mole) in a 50 mL flask containing a stir bar and fitted with a

reflux condenser. The resulting mixture was stirred for 16 hours at room temperature, and then the resulting upper fluorochemical phase was separated from the resulting lower sulfuric acid phase. Gas-liquid chromatographic (GLC) analysis of the fluorochemical phase revealed the presence of only the starting perfluorocompound and no detectable amount of  $C_3F_9CO_2CH_3$ , the expected product of hydrolysis. This result (indicating that the perfluorocompound was stable in the presence of the acid) was surprising in view of the discussion by England in J.Org. Chem. 49, 4007 (1984), which states that "[f]luorine atoms attached to carbon which also bears an alkyl ether group are known to be labile to electrophilic reagents. They are readily hydrolyzed in concentrated sulfuric acid, thus providing a route to some esters of fluoroacids."

Stability in the Presence of Oxidant

To assess oxidative stability, potassium permanganate (20 g, 0.126 mole) was dissolved in acetone, and  $C_4F_9OCH_3$  (500 g of 99.9% purity, 2.0 mole) was added to the resulting solution. The solution was refluxed for four hours, with no indication that the permanganate had been consumed (as evidenced by the absence of brown  $MnO_2$ ). The refluxed solution was then distilled into a 500 mL Barrett trap filled with water. The lower fluorochemical phase of the resulting mixture was separated from the upper phase, was washed with four 1.5 L aliquots of water, and was dried by passage through a column of silica gel to yield 471 g of resulting product. Gas chromatographic analysis of the

product revealed no evidence of degradation of the starting perfluorocompound, indicating that the compound was stable in the presence of the oxidant.

5 Flash Point Testing

The alkoxy-substituted perfluorocompounds  $C_4F_9OCH_3$ ,  $C_4F_9OC_2H_5$ , and  $c-C_6F_{11}OCH_3$  were tested for flash point by the standard method defined by ASTM D3278-89. Each compound was determined to have no flash point.

10

Examples 1-7 describe the preparation of novel alkoxy-substituted perfluorocompounds of the invention.

Example 1

15 Preparation of  $c-C_6F_{11}CF_2OC_2H_5$

A one liter jacketed round bottom flask was equipped with a reflux condenser, an overhead stirrer, and an addition funnel. The flask was charged with anhydrous dimethyl formamide (300 g) and diethyl sulfate (239 g, 1.55 mole) under a flow of dry nitrogen gas. The resulting stirred solution was cooled to  $-20^{\circ}C$ , and spray-dried potassium fluoride (Aldrich Chemical, which was further dried at  $120^{\circ}C$ , 67.5 g, 1.16 mole) was added. A mixture of 20 perfluorocyclohexane carbonyl fluoride and isomers of perfluoro methylcyclopentane carbonyl fluoride (approximately 80% purity, 318 g, 0.77 mole) was then added to the resulting mixture over a period of 25 45 minutes. (Hereinafter,  $c-C_6F_{11}-$  refers to a mixture 30 of the perfluorinated cyclohexyl and methyl cyclopentyl isomers.) The mixture was held at  $-20^{\circ}C$  for two hours

and then allowed to come to ambient temperature while stirring overnight. The mixture was transferred to a two liter round bottom flask and was heated to 50°C for one hour. One liter of water was added and the 5 resulting mixture distilled. The lower fluorochemical phase of the resulting distillate was then separated from the upper phase and was washed once with water to afford 236 g of 61.9 % purity  $c\text{-C}_6\text{F}_{11}\text{CF}_2\text{OC}_2\text{H}_5$ . The product was distilled to a purity of 99% (b.=128-10 134°C). The product identity was confirmed by gas chromatography/ mass spectrometry (GCMS) and by  $^1\text{H}$  and  $^{19}\text{F}$  nuclear magnetic resonance spectroscopy (NMR).

Example 2

15 Preparation of  $c\text{-C}_6\text{F}_{11}\text{CF}_2\text{OCH}_3$

A 500 mL round bottom flask was equipped with an overhead stirrer, a condenser, and an addition funnel, and was then charged with spray-dried potassium fluoride (Aldrich, which was further dried at 120°C, 20 39.8 g, 0.68 mole) and anhydrous dimethyl formamide (250 g).  $c\text{-C}_6\text{F}_{11}\text{COF}$  (150 g of 70% purity, 0.32 mole) was added slowly to the resulting mixture at room temperature. An ice bath was then placed around the flask, and dimethyl sulfate (74.8 g, 0.59 mole) was 25 added dropwise. The resulting mixture was held in the ice bath for five hours, followed by warming to ambient temperature with stirring overnight. Water (100 mL) was then added to the mixture, and the resulting product was distilled. The lower fluorochemical phase of the 30 resulting distillate was separated from the upper aqueous phase to yield 143 g of  $c\text{-C}_6\text{F}_{11}\text{CF}_2\text{OCH}_3$  of 63%

purity. The products of several reactions were combined and distilled (b.=110-120°C). The product identity was confirmed by GCMS and by <sup>1</sup>H and <sup>19</sup>F NMR.

5    **Example 3**

**Preparation of 4-CF<sub>3</sub>-c-C<sub>6</sub>F<sub>10</sub>CF<sub>2</sub>OCH<sub>3</sub>**

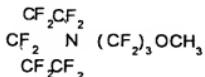
A one liter round bottom flask was equipped with an overhead stirrer, a condenser, and an addition funnel and was then charged with spray-dried potassium 10 fluoride (Aldrich, which was further dried at 120°C, 15.4 g, 0.26 mole), anhydrous cesium fluoride (6.5 g, 0.043 mole), and anhydrous dimethyl formamide (250 g). A mixture of perfluoro-4-methylcyclohexane carbonyl fluoride and perfluorodimethyl cyclopentane carbonyl 15 fluorides (100 g of 72% purity, 0.189 mole) was then added to the resulting mixture, and the mixture was stirred at ambient temperature for four hours. Dimethyl sulfate (33.3 g, 0.264 mole) was then added to the stirred mixture, and the mixture was further 20 stirred for 72 hours followed by addition of water (500 mL).

The mixture was worked up essentially as described in Example 1 to yield 67 g of a mixture of several components, which was subsequently distilled to 25 give 26.5 g of 4-CF<sub>3</sub>-c-C<sub>6</sub>F<sub>10</sub>CF<sub>2</sub>OCH<sub>3</sub> (b.=118-137°C) of 88% purity. The product identity was confirmed by GCMS and by <sup>1</sup>H and <sup>19</sup>F NMR, which showed the product to be about 60% of the trans-1,4 isomer and 15% of the cis-1,4 isomer. The product also contained several other 30 isomers of CF<sub>3</sub>-c-C<sub>6</sub>F<sub>10</sub>CF<sub>2</sub>OCH<sub>3</sub>, resulting from isomers of

the perfluoromethylcyclohexane carbonyl fluoride which were present in the starting material.

**Example 4**

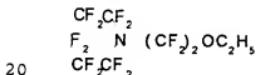
5 **Preparation of**



The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (27 g, 0.46 mole), anhydrous dimethyl formamide (250 g), 10 perfluoro-3-piperidinopropionyl fluoride (322 g of 40.4% purity, 0.32 mole), and dimethyl sulfate (52 g, 0.41 mole). 275 g of a product mixture of 38% purity was obtained, which was fractionally distilled to give a main fraction of the desired compound (b.=137-139°C, 15 91% purity). The product identity was confirmed by infrared spectroscopy (IR), GCMS, and <sup>1</sup>H and <sup>19</sup>F NMR.

**Example 5**

**Preparation of**

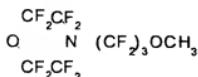


The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (42 g, 0.72 mole), anhydrous dimethyl formamide (300 g), perfluoro-2-piperidinoacetyl fluoride (354 g of 47.2% 25 purity, 0.46 mole), and diethyl sulfate (94 g, 0.61 mole). 349 g of a product mixture of 39% purity was obtained, which was fractionally distilled to give a main fraction of the desired compound (b.=135-137°C).

The product identity was confirmed by IR, GCMS, and  $^1\text{H}$  and  $^{19}\text{F}$  NMR.

Example 6

5 Preparation of



The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (17.7 g, 0.30 mole), anhydrous dimethyl formamide (300 g), perfluoro-3-morpholinopropionyl fluoride (890 g of 8.6% purity, 0.2 mole), and dimethyl sulfate (37 g, 0.29 mole). 88 g of a product mixture of 57% purity was obtained, which was fractionally distilled to give a main fraction of the desired compound (b.p.=129°C, 90% purity). The product identity was confirmed by IR, GCMS, and  $^1\text{H}$  and  $^{19}\text{F}$  NMR.

Example 7

Preparation of  $\text{CH}_3\text{OCF}_2\text{-c-C}_6\text{F}_{10}\text{CF}_2\text{OCH}_3$

20 The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (6.62 g, 0.011 mole), anhydrous dimethyl formamide (200 g),  $\text{FCO-c-C}_6\text{F}_{10}\text{COF}$  (253 g of approximately 26% purity, 0.185 mole; the remainder of the material 25 comprised a mixture of mono-functional, non-functional, and isomeric compounds), and dimethyl sulfate (14.4 g, 0.011 mole). 21 g of solid  $\text{CH}_3\text{OCF}_2\text{-c-C}_6\text{F}_{10}\text{CF}_2\text{OCH}_3$ , was obtained (product identity confirmed by IR and  $^1\text{H}$  and  $^{19}\text{F}$  NMR).

Examples 8-28 describe the use of alkoxy-substituted perfluorocompounds in various different cleaning applications according to the cleaning process of the 5 invention.

A number of different alkoxy-substituted perfluorocompounds were prepared for use in cleaning, as described below:

10

Preparation of  $C_4F_9OC_2H_5$

A 20 gallon Hastalloy C reactor, equipped with a stirrer and a cooling system, was charged with spray-dried potassium fluoride (7.0 kg, 120.3 mole). The 15 reactor was sealed, and the pressure inside the reactor was reduced to less than 100 torr. Anhydrous dimethyl formamide (22.5 kg) was then added to the reactor, and the reactor was cooled to below 0°C with constant agitation. Heptafluorobutyryl fluoride (22.5 kg of 58% 20 purity, 60.6 mole) was added to the reactor contents. When the temperature of the reactor reached -20°C, diethyl sulfate (18.6 kg, 120.8 mole) was added to the reactor over a period of approximately two hours. The resulting mixture was then held for 16 hours with 25 continued agitation, was raised to 50°C for an additional four hours to facilitate complete reaction, and was cooled to 20°C. Then, volatile material (primarily perfluorooxacyclopentane present in the starting heptafluorobutyryl fluoride) was vented from 30 the reactor over a three-hour period. The reactor was

then resealed, and water (6.0 kg) was added slowly to the reactor. After the exothermic reaction of the water with unreacted perfluorobutyryl fluoride subsided, the reactor was cooled to 25°C, and the 5 reactor contents were stirred for 30 minutes. The reactor pressure was carefully vented, and the lower organic phase of the resulting product was removed to afford 17.3 kg of material which was 73%  $C_4F_9OC_2H_5$  (b.p.=75°C). The product identity was confirmed by 10 GCMS and by  $^1H$  and  $^{19}F$  NMR.

Preparation of  $C_4F_9OCH_3$ ,

The reaction was carried out in the same equipment and in a similar manner to the procedure of 15 Example 7 above, but using the following materials: spray-dried potassium fluoride (6 kg, 103.1 mole), anhydrous dimethyl formamide (25.1 kg), perfluorobutyryl fluoride (58% purity, 25.1 kg, 67.3 mole), and dimethyl sulfate (12.0 kg, 95.1 mole). 20 22.6 kg of product was obtained, which was 63.2%  $C_4F_9OCH_3$  (b.=58-60°C). The product identity was confirmed by GCMS and by  $^1H$  and  $^{19}F$  NMR.

Preparation of  $c-C_6F_{11}OCH_3$ ,

25 A 500 ml, 3-necked round bottom flask equipped with an overhead stirrer, an addition funnel, and a condenser was charged with anhydrous cesium fluoride (27.4 g, 0.18 mole), anhydrous diethylene glycol dimethyl ether (258 g, hereinafter diglyme), and 30 dimethyl sulfate (22.7 g, 0.18 mole). Perfluorocyclohexanone (50g, 0.18 mole) was then added

dropwise to the resulting stirred mixture, and stirring was continued for 18 hours after the addition. Water (approximately 200 ml) was added to the resulting mixture, and the lower fluorochemical phase of the 5 mixture was separated from the upper phase and washed once with saturated aqueous sodium chloride solution. Since the fluorochemical phase still contained about 12% diglyme, water was added to it, and the resulting product was azeotropically distilled to yield 32.8 g of 10  $c\text{-C}_6\text{F}_{11}\text{OCH}_3$  (b.p.=100°C), which was free of diglyme. The product identity was confirmed by IR, GCMS, and  $^1\text{H}$  and  $^{19}\text{F}$  NMR.

Preparation of  $(\text{CF}_3)_2\text{CFCF}_2\text{OCH}_3$ ,

15 The title compound was prepared essentially as in Example 1 using anhydrous potassium fluoride (31.9 g, 0.55 mole), anhydrous dimethyl formamide (186 g), perfluoroisobutryl fluoride (108 g of 99% purity, 0.5 mole), and dimethyl sulfate (81.9 g, 20 0.65 mole). The resulting mixture was held at -20°C for 16 hours, was warmed to 40°C for 3.5 hours, and was then distilled to yield 109 g of the title compound (83.6% purity by GLC; also containing 11.6%  $(\text{CF}_3)_2\text{CFCOF}$ ). The reaction mixtures from several runs were combined and 25 distilled (b.=60-61°C).

Preparation of  $(\text{CF}_3)_2\text{CFCF}_2\text{OC}_2\text{H}_5$ ,

The title compound was prepared essentially as in Example 1 using anhydrous potassium fluoride 30 (31.9 g, 0.55 mole), anhydrous dimethyl formamide (184 g), perfluoroisobutryl fluoride (112.3 g of 77%

purity, 0.4 mole), and diethyl sulfate (100.1 g, 0.65 mole). The resulting mixture was worked up essentially as in Example 3 to yield 80 g of the title compound. The product identity was confirmed by IR, 5 GCMS, and <sup>1</sup>H and <sup>19</sup>F NMR.

**Preparation of C<sub>8</sub>F<sub>17</sub>OCH<sub>3</sub>**

The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride 10 (6.62 g, 0.011 mole), anhydrous dimethyl formamide (800 g), C<sub>7</sub>F<sub>15</sub>COF (456.7 g, 1.09 mole), and dimethyl sulfate (14.4 g, 0.011 mole). The resulting mixture was worked up essentially as in Example 3 to give 444 g of the title compound (99.7% purity, b.=142-144°C). 15 The product identity was confirmed by IR, GCMS, and <sup>1</sup>H and <sup>19</sup>F NMR.

**Preparation of C<sub>2</sub>F<sub>5</sub>CF(OCH<sub>3</sub>)CF(CF<sub>3</sub>)<sub>2</sub>**

The title compound was prepared essentially 20 as in Example 3 using anhydrous potassium fluoride (7.2 g, 0.123 mol), anhydrous diethylene glycol dimethyl ether (diglyme, 60 g), methyltrialkyl(C<sub>8</sub>-C<sub>10</sub>)ammonium chloride (Adogen™ 464, available from Aldrich Chemical Company, 1.8 g), 25 C<sub>2</sub>F<sub>5</sub>COCF(CF<sub>3</sub>)<sub>2</sub> (30 g, 0.095 mol, prepared by the reaction of pentafluoropropionyl fluoride with KF and hexafluoropropene), and dimethyl sulfate (15.5 g, 0.123 mol). The reaction mixture was stirred at room temperature for 72 hours. Approximately 100 mL of 10% 30 aqueous potassium hydroxide was then added to the reaction mixture, and the resulting product was

azeotropically distilled from the mixture. The lower phase of the resulting distillate was separated from the upper phase, was washed with water, and was distilled to give 26.7 g of product ether (boiling range 90-92°C; >99% purity by gas-liquid chromatography (GLC)). The product identity was confirmed by GCMS and <sup>1</sup>H and <sup>19</sup>F NMR.

Preparation of C<sub>2</sub>F<sub>5</sub>OCH<sub>3</sub>

10 A jacketed one liter round bottom flask was equipped with an overhead stirrer, a solid carbon dioxide/acetone condenser, and an addition funnel. The flask was charged with spray-dried potassium fluoride (85 g, 1.46 mol) and anhydrous diethylene glycol  
15 dimethyl ether (375 g) and was then cooled to about -20°C using a recirculating refrigeration system. C<sub>2</sub>F<sub>5</sub>COF (196 g, 1.18 mol) was added to the flask over a period of about one hour. The flask was then warmed to about 24°C, and dimethyl sulfate (184.3 g, 1.46 mol) was  
20 then added dropwise via the addition funnel over a 45 minute period. The resulting mixture was then stirred at room temperature overnight. Water (a total of 318 mL) was then added dropwise to the mixture. The mixture was transferred to a one liter round bottom  
25 flask, and the resulting product ether was azeotropically distilled. The lower product phase of the resulting distillate was separated from the upper aqueous phase, was washed once with cold water, and was subsequently distilled to give 180 g of product (b.p.  
30 36°C; >99.9% purity by GLC). The product identity was confirmed by GCMS and by <sup>1</sup>H and <sup>19</sup>F NMR.

Preparation of  $\text{CF}_3\text{CF}(\text{OCH}_3)\text{CF}(\text{CF}_3)_2$

The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (12.8 g, 0.22 mol), anhydrous diethylene glycol dimethyl ether (diglyme, 106 g), methyltrialkyl( $\text{C}_8\text{-C}_{10}$ )ammonium chloride (Adogen™ 464, available from Aldrich Chemical Company, 4 g),  $\text{CF}_3\text{COCF}(\text{CF}_3)_2$  (53.2 g, 0.20 mol, prepared essentially by the procedure of Smith et al., J. Am. Chem. Soc., 84, 4285 (1962)), and dimethyl sulfate (33.9 g, 0.72 mol). Aqueous potassium hydroxide was added to the reaction mixture (approximately 25 g of 50% solution), followed by water (200 mL). The resulting crude product was azeotropically distilled from the reaction mixture. The lower phase of the resulting distillate was separated from the upper phase, was washed with water, was dried over anhydrous sodium sulfate, and was distilled (b.p. 82-83°C; yield of 45 g). The product identity was confirmed by GCMS and by FTIR.

Preparation of  $\text{C}_5\text{F}_{11}\text{OCH}_3$

The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (32 g, 0.55 mol), anhydrous diethylene glycol dimethyl ether (diglyme, 375 g), methyltrialkyl( $\text{C}_8\text{-C}_{10}$ )ammonium chloride (Adogen™ 464, available from Aldrich Chemical Company, 12.5 g),  $\text{C}_4\text{F}_9\text{COF}$  (218 g of 60.7% purity, 0.5 mol), and dimethyl sulfate (69.3 g, 0.55 mol). The reaction mixture was stirred at room temperature overnight. Approximately 100 mL of 10% aqueous

potassium hydroxide was then added to the mixture, and the resulting product was azeotropically distilled from the mixture. The lower phase of the resulting distillate was separated from the upper phase, was 5 washed with water, was treated with aqueous potassium hydroxide solution (53 g of 50%), and was then refluxed for one hour. A second azeotropic distillation and water washing yielded crude product which was further purified by distillation through a ten-plate perforated 10 column to provide the product ether (boiling range 82-84°C; 96.2% purity by GLC). The product identity was confirmed by GCMS and by <sup>1</sup>H and <sup>19</sup>F NMR.

Preparation of C<sub>5</sub>F<sub>11</sub>OC<sub>2</sub>H<sub>5</sub>

15 The title compound was prepared essentially as in Example 3 using anhydrous potassium fluoride (38.6 g, 0.67 mol), anhydrous diethylene glycol dimethyl ether (diglyme, 500 g), methyltrialkyl(C<sub>8</sub>-C<sub>10</sub>)ammonium chloride (Adogen™ 464, 20 available from Aldrich Chemical Company, 10.5 g), C<sub>4</sub>F<sub>9</sub>COF (260 g of 60.7% purity, 0.59 mol), and diethyl sulfate (102.4 g, 0.67 mol). The reaction mixture was stirred at room temperature overnight, and then the resulting product was azeotropically distilled from the 25 reaction mixture. The lower product phase of the resulting distillate was separated from the upper phase and was treated with approximately 50 g of 50% aqueous potassium hydroxide, was refluxed for four hours, and was stirred at room temperature overnight. A second 30 azeotropic distillation and water washing gave crude product which was further purified by distillation

through a ten-plate perforated column to provide the product ether (boiling point 96°C; 99.6% purity by GLC). The product identity was confirmed by GCMS and by <sup>1</sup>H and <sup>19</sup>F NMR.

5

#### Solvency Properties

A number of potential solvents were tested for their ability to dissolve hydrocarbons of increasing molecular weight according to the procedure described 10 in U.S. Patent No. 5,275,669 (Van Der Puy et al.), the description of which is incorporated herein by reference. The data shown in Table 1 were obtained by determining the largest normal hydrocarbon alkane which was soluble in a particular solvent at a level of 50 15 percent by volume. The numbers in the Table correspond with the carbon number of the largest alkane, e.g., "8" refers to octane. Measurements were made from room temperature up to the boiling point of the solvent. For comparative purposes, hydrofluorocarbons (HFCs) and 20 perfluorocarbons (PFCs) were also tested using this method.

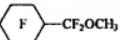
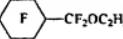
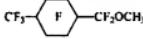
Table 1

Temperature (°C)	C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>	C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub>	C-C <sub>6</sub> F <sub>11</sub> OCH <sub>3</sub>	CF <sub>3</sub> CFHCFC <sub>2</sub> F <sub>5</sub>	C <sub>6</sub> F <sub>14</sub>	C <sub>8</sub> F <sub>18</sub>	C <sub>5</sub> F <sub>11</sub> H	C <sub>6</sub> F <sub>13</sub> H
23	9	12	10	7	6	5	7	7
30	10	12	11	7				
40	10	13	11	8	6	6	8	8
50	12	14	13	8	7	6		8
55	12	15	13	9				
60	12	15	13		7	7	9	
73		17	15			7		10
101			18			9		

The data in Table 1 show that hydrocarbon alkanes are significantly more soluble in the alkoxy-substituted perfluorocompounds used in the cleaning process of this invention than in the comparative 5 compounds, the HFCs and PFCs. This improved solvency was more pronounced at elevated temperatures. Thus, the cleaning process of the invention can be used to remove higher molecular weight hydrocarbons (e.g., oils and greases) from substrate surfaces than can be 10 removed using HFCs or PFCs. The higher solvency of the alkoxy-substituted perfluorocompounds for hydrocarbon alkanes indicates that these perfluorocompounds can serve not only as superior cleaning solvents for removing hydrocarbon soils, but can also be effective 15 as solvents for depositing hydrocarbon coatings, e.g., coatings of lubricant, onto substrate surfaces.

Using essentially the above-described method, the solvency properties of other alkoxy-substituted perfluorocompounds were tested at room temperature. 20 The compounds tested and the results obtained are shown in Table 2 below.

Table 2

Compound	Largest Soluble
	9
	11
$C_8F_{17}OCH_3$	6
$(CF_3)_2CFCF_2OCH_3$	9
$C_2F_5CF(OCH_3)CF(CF_3)_2$	8
$CF_3CF(OCH_3)CF(CF_3)_2$	9
$C_3F_7OCH_3$	10
$C_5F_{11}OCH_3$	8
$C_5F_{11}OC_2H_5$	10
	8
	7
	9
	8

Examples 8-10 and Comparative Examples A-C

In the following Examples and Comparative Examples, the cleaning ability of the alkoxy-substituted perfluorocompounds used in the cleaning

process of the invention was further evaluated. A 1.28 cm x 1.28 cm x 0.225 cm wire-wrapped, aluminum coupon was coated with white heavy mineral oil (available from Aldrich Chemical) by immersing the 5 coupon in an oil-filled beaker. The initial amount of the oil on the coupon was determined by weighing it on an analytical balance to the nearest 0.1 mg. The coupon was immersed in a container of solvent and sonicated for 1 minute at the indicated temperature 10 (see Table 3 below for the solvents and temperatures used). The coupon was then weighed again, and the results were recorded in Table 3 as percent oil removal.

Table 3

Example	8	9	10	Comparative A	Comparative B	Comparative C
Temp. (°C)	C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>	C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub>	C-C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>	C <sub>6</sub> F <sub>14</sub>	C <sub>6</sub> F <sub>13</sub> H	CF <sub>2</sub> ClCFCl <sub>2</sub>
23	60.3	56.0	74.4	54.9	71.7	98.9
50	98.7	99.2	96.5	67.6	86.8	98.7
60	99.9	100.0	99.8			

The data in Table 3 show that the alkoxy-substituted perfluorocompounds removed amounts of the mineral oil which were comparable to the amounts removed by the comparative PFC and HFC compounds at 5 room temperature. At elevated temperature, the cleaning properties of the perfluorocompounds were superior to those of the PFC and HFC compounds and equivalent to those of the comparative CFC compound.

10 Examples 11-13

Using essentially the same procedure as that described in Examples 8-10, the ability of the alkoxy-substituted perfluorocompounds to remove a fluorinated oil was evaluated. As in the previous Examples, a 15 coupon was immersed in Krytox™ 157FSM perfluoropolyether oil having carboxylic acid end groups (available from DuPont), and the percent oil remaining after immersion in the solvent (at room temperature) was determined. The results are shown in 20 Table 4 below.

Table 4

Example	11	12	13
Compound	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C-C_6F_{11}OCH_3$
% Removed	99.1	99.3	96.5

25 The data show that the alkoxy-substituted perfluorocompounds very effectively removed the perfluoropolyether oil from the surface of the coupon. This indicates that the perfluorocompounds can function

well as cleaning solvents for the removal of halogenated compounds such as halogenated oils and greases.

Examples 14-16 and Comparative Examples D-E

5 The ability of alkoxy-substituted perfluorocompounds to function as a rinse agent in a co-solvent cleaning process was evaluated. The above-described aluminum coupon was coated with solder flux (available from Alpha Metals as Alpha 611 rosin, mildly activated flux) 10 by immersing the coupon into a flux-filled beaker. The flux-coated coupon was then dried using a forced air convection drier. The initial amount of the flux on the coupon was determined by weighing it on an analytical balance to the nearest 0.1 mg. The coupon 15 was immersed in a container of a mixed solvating agent comprising approximately 50% methyl decanoate and 50% dipropylene glycol di-n-butyl ether and was sonicated for 1 minute at approximately 55°C. The coupon was then immersed for 30 seconds into alkoxy-substituted 20 perfluorocompound which had been heated to its boiling point. The coupon was weighed again, and the results were recorded in Table 5 below as percent oil removed from the coupon.

25

Table 5

Example	14	15	16	Comparative D	Comparative E
Compound	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{11}OCH_3$	$C_6F_{14}$	$C_6F_{13}H$
% Removed	100.0	100.0	100.0	51.9	91.2

The data in Table 5 show that the alkoxy-substituted perfluorocompounds (used according to the cleaning process of the invention) effectively removed the solvating agent and flux residues, showing solvency properties superior to those of the comparative PFC and HFC compounds.

Examples 17-18 and Comparative Example F

The above-described aluminum coupon was dipped 10 into Brayco 815Z perfluoropolyether oil (available from Castrol Inc., molecular weight of about 10,000) and then immersed in alkoxy-substituted perfluorocompound vapor (over the boiling liquid) for 60 seconds. The percent oil removal was determined in the above-15 described manner. The results are shown in Table 6.

Table 6

	17	18	Comparative F
Compound	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{14}$
Percent Soil Removed	89.9%	93.3%	92.9%

20 Examples 19-20 and Comparative Example G

The above-described test coupon was dipped into a paraffinic oil comprising a mixture of linear and branched hydrocarbons (DuoSeal Pump Oil, available from Sargent Welch), was immersed in mixed solvating agent 25 comprising approximately 50% methyl caproate and 50% dipropylene glycol di-n-butyl ether for 30 seconds, and was then rinsed in boiling alkoxy-substituted

perfluorocompound for 30 seconds. The percent oil removal was determined in the above-described manner. The results are shown in Table 7.

5

Table 7

	19	20	Comparative G
Compound	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{14}$
Percent Soil Removed	99.8%	100.0%	69.2%

Examples 21-22

The above-described test coupon was dipped in 10 white heavy mineral oil (available from Aldrich Chemical), was immersed in a boiling single-phase mixture of 40 volume % of a solvating agent comprising essentially methyl decanoate and 60 volume % of alkoxy-substituted perfluorocompound (a cleaning composition 15 of the invention) for 60 seconds, was cooled for 60 seconds, and was then immersed in mixture vapor for 30 seconds. The percent oil removal was determined in the above-described manner. The results are shown in Table 8.

20

Table 8

	21	22
Fluorinated Component of Cleaning Composition	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$
Percent Soil Removed	94.61%	94.28%

Examples 23-24 and Comparative Example H

The above-described test coupon was dipped into DuoSeal Pump Oil (available from Sargent-Welch), was immersed in a boiling mixture of 40 volume % of a 5 solvating agent comprising mixed terpenes having a boiling range of 243-274°C and 60 volume % of alkoxy-substituted perfluorocompound (a cleaning composition of the invention), was cooled for 60 seconds, and was then immersed in mixture vapor for 30 seconds. The 10 percent oil removal was determined in the above-described manner. The results are shown in Table 9.

Table 9

	23	24	Comparative H
Fluorinated Component of Cleaning Composition	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{14}$
Percent Soil Removed	86.4%	99.4%	75.7%

15

Examples 25-26 and Comparative Example I

The above-described test coupon was dipped into DuoSeal Pump Oil (available from Sargent-Welch) and was then immersed in a mixture of 40 volume %  $n-C_6H_{14}$  and 60 20 volume % alkoxy-substituted perfluorocompound (a cleaning composition of the invention) for 60 seconds at room temperature with ultrasonic agitation. The percent oil removal was determined in the above-described manner. The results are shown in Table 10.

25

Table 10

	25	26	Comparative I
Fluorinated Component of Cleaning Composition	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{14}$
Percent Soil Removed	92.5%	99.0%	88.5%

Examples 27-28 and Comparative Example J

5        The above-described test coupon was dipped into DuoSeal Pump Oil (available from Sargent-Welch) and was then immersed in the vapor of a boiling mixture of 40 volume %  $n\text{-}C_6H_{14}$  and 60 volume % alkoxy-substituted perfluorocompound (a cleaning composition of the 10 invention) for 60 seconds. The percent oil removal was determined in the above-described manner. The results are shown in Table 11.

Table 11

Example	27	28	Comparative J
Fluorinated Component of Cleaning Composition	$C_4F_9OCH_3$	$C_4F_9OC_2H_5$	$C_6F_{14}$
Percent Soil Removed	90.8%	97.1%	73.8%

15

The results obtained in Examples 17-28 show that 20 alkoxy-substituted perfluorocompounds are effective at removing a variety of contaminants from substrate surfaces.

In Examples 29 to 70 the process of cleaning textiles using alkoxy-substituted perfluoroalkanes was demonstrated. The cleaning compositions used were as follows:

Cleaning  
composition

A	C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub> (neat)
B	C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub> (neat)
C	0.5 wt.% C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> F <sub>4</sub> OCF <sub>2</sub> C(O)NHC <sub>2</sub> H <sub>4</sub> OH, 0.2 wt.% Brij 30 <sup>TM</sup> in C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>
D	0.5 wt.% C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> F <sub>4</sub> OCF <sub>2</sub> C(O)NHC <sub>2</sub> H <sub>4</sub> OH, 0.2 wt.% Igepal CO-210 <sup>TM</sup> in C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>
E	0.5 wt.% FC-171 <sup>TM</sup> , 0.2 wt.% TRITON X-15 <sup>TM</sup> , in C <sub>4</sub> F <sub>9</sub> OCH <sub>3</sub>
F	0.5 wt.% FC-171 <sup>TM</sup> , 0.2 wt.% TRITON X-15 <sup>TM</sup> , in C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub>

5 BRIJ 30<sup>TM</sup> is an ethoxylated (poly)ethylene oxide available from ICI Chemical  
IGEPAL CO-210<sup>TM</sup> is a nonylphenoxyethoxylate) is available from Rhone-Poulenc  
TRITON X-15<sup>TM</sup> is an octylphenoxyethoxylate) is available  
10 from Union Carbide  
FC-171<sup>TM</sup> is a fluorinated sulfonamide surfactant available from 3M Company, St. Paul, MN  
C<sub>4</sub>F<sub>9</sub>OC<sub>2</sub>F<sub>4</sub>OCF<sub>2</sub>C(O)NHC<sub>2</sub>H<sub>4</sub>OH may be prepared by the method described in U.S. 5,125,978 (Flynn, et al.) and U.S.  
15 5,089,152 (Flynn et al.)

In these Examples, fabric samples measuring about 15 x 15 cm and weighing about 10 grams were stained by adding three drops of mineral oil, and separately,

three drops of corn oil, to the fabric, covering the stain with wax paper, and applying a 500 g weight for about one minute to ensure oil penetration into the fabric. The samples were then allowed to stand for 5 about thirty minutes prior to each cleaning trial.

The stained fabrics were placed into individual quart glass jars with 200 mL of a cleaning solution, capped, and then shaken for ten minutes. The cleaning solution was then drained and the fabric samples rinsed 10 with 200 mL of the same neat alkoxy-substituted perfluoroalkane for five minutes, followed by air drying. The rinse step was omitted in Examples in which the neat fluorinated ether was used as the cleaning solution.

15 The fabric samples were evaluated visually comparing the size and appearance of the stain on the untreated fabric to that of the cleaned fabric. The stains were then evaluated with a Model CR-300<sup>TM</sup> Chromometer (Minolta Camera, Japan) to quantify the 20 color of the stain before and after cleaning. Results are tabulated in the Tables below, organized by the identity of the Oil and Fabric tested. In the tables, the value  $\Delta E$  represents the difference in color measurements between a stained and an unstained portion 25 of the same fabric sample. In practice, a cleaned stain should have a Delta E value that is lower than an untreated (stained but not cleaned) sample.

Table 12

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
29 Control	Untreated	Corn Oil	65/35 Polyester Cotton Twill	7.1 $\pm 0.04$	
30	A	"	"	4.52 $\pm 0.04$	Spot size decreased to 2/3
31	B	"	"	4.58 $\pm 0.06$	Spot size decreased to 2/3
32	C	"	"	4.56 $\pm 0.00$	Spot size decreased to 1/2
33	D	"	"	5.26 $\pm 0.04$	Spot size decreased to 1/2
34	E	"	"	3.54 $\pm 0.12$	Spot size decreased to less than 1/2
35	F	"	"	4.56 $\pm 0.23$	Spot size decreased to less than 1/4

Table 13

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
36 Control	Untreated Corn Oil	100% Cotton style 400		0.27 $\pm 0.03$	Spot size decreased to 1/2
37	A	"	"	1.86 $\pm 0.30$	Spot size decreased to 1/4
38	B	"	"	2.6 $\pm 0.04$	Spot size decreased to less than 1/2
39	C	"	"	0.39 $\pm 0.07$	Spot size nearly gone
40	D	"	"	0.34 $\pm 0.06$	Spot size decreased to 1/4
41	E	"	"	0.88 $\pm 0.01$	Spot size decreased to 1/2
42	F	"	"	0.76 $\pm 0.05$	Spot size decreased to 1/4

Table 14

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
43 Control	Untreated	Corn Oil	100 % Wool	11.41 $\pm 0.75$	
44	A	"	"	10.46 $\pm 0.13$	No Change
45	B	"	"	8.87 $\pm 0.07$	No Change
46	C	"	"	8.96 $\pm 0.16$	No Change
47	D	"	"	9.78 $\pm 0.08$	No Change
48	E	"	"	8.74 $\pm 0.22$	No Change
49	F	"	"	8.54 $\pm 0.06$	No Change

Table 15

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
50 Control	Untreated	Light Mineral Oil	65/35 Polyester Cotton Twill	5.80 $\pm 0.03$	
	"	"	"	0.50 $\pm 0.07$	Spot not visible
51	A				
52	B	"	"	0.14 $\pm 0.16$	Spot not visible
53	C	"	"	0.44 $\pm 0.04$	Spot not visible
54	D	"	"	0.36 $\pm 0.06$	Spot not visible
55	E	"	"	0.44 $\pm 0.19$	Spot not visible
56	F	"	"	0.20 $\pm 0.05$	Spot not visible

Table 16

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
57	Untreated	Heavy Mineral Oil	100% Cotton style 400	0.40 ±0.06	
58	A	"	"	0.37 ±0.28	Not visible
59	B	"	"	0.13 ±0.08	Not visible
60	C	"	"	0.22 ±0.04	Not visible
61	D	"	"	0.17 ±0.06	Not visible
62	E	"	"	0.15 ±0.01	Not visible
63	F	"	"	1.20 ±0.08	Not visible

Table 1.7

Example	Cleaning Solution	Oil	Fabric	$\Delta E$	Visual Observation
64	Untreated	Heavy Mineral Oil	100% Wool	8.58	
Control		"		$\pm 0.33$	
65	A	"	"	0.76	Faintly visible
				$\pm 0.16$	
66	B	"	"	0.84	Faintly visible
				$\pm 0.13$	
67	C	"	"	0.67	Faintly visible
				$\pm 0.10$	
68	D	"	"	0.39	Not visible
				$\pm 0.01$	
69	E	"	"	0.57	Not visible
				$\pm 0.21$	
70	F	"	"	0.79	Not visible
				$\pm 0.04$	

As can be seen in the above Tables, the mineral oil stains were essentially completely removed with all cleaning solutions, based on both visual and colorimetric analysis. The corn oil stains remained to 5 some degree on all fabrics. The polyester/cotton samples showed a decrease in stain size (diameter) and a lighter (less color) stain than with the untreated control, but addition of a surfactant to the alkoxy-substituted perfluoroalkane was more effective in 10 reducing the size and color of the stain. On the 100% cotton samples, the neat alkoxy-substituted perfluoroalkane reduced the size of the stain, but made the stain darker by the colorimetric measurements.

Various modifications and alterations of this 15 invention will be apparent to those skilled in the art without departing from the scope and spirit of this invention.

We claim:

1. A dry cleaning process for removing  
contaminants from the surface of a fabric substrate,  
5 the process comprising the step of contacting a fabric  
substrate with a liquid- and/or vapor-phase cleaning  
composition comprising at least one mono-, di-, or  
trialkoxy-substituted perfluoroalkane,  
perfluorocycloalkane, perfluorocycloalkyl-containing  
10 perfluoroalkane, or perfluorocycloalkylene-containing  
perfluoroalkane compound, said compound optionally  
containing one or more additional catenary heteroatoms.

2. The process of Claim 1 wherein said compound  
15 has a boiling point in the range of from about 25°C to  
about 200°C.

3. The process of Claim 1 wherein said compound  
is represented by the general formula  
20



wherein x is an integer of 1 to 3; when x is 1,  $R_f$  is  
selected from the group consisting of linear or  
25 branched perfluoroalkyl groups having from 2 to about  
15 carbon atoms, perfluorocycloalkyl-containing  
perfluoroalkyl groups having from 5 to about 15 carbon  
atoms, and perfluorocycloalkyl groups having from 3 to  
about 12 carbon atoms; when x is 2,  $R_f$  is selected from  
30 the group consisting of linear or branched

perfluoroalkanediyl groups or perfluoroalkylidene groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-containing perfluoroalkanediyl or perfluoroalkylidene groups having from 6 to about 15 carbon atoms, and perfluorocycloalkanediyl groups or perfluorocycloalkylidene groups having from 3 to about 12 carbon atoms; when x is 3, R<sub>f</sub> is selected from the group consisting of linear or branched perfluoroalkanetriyl groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-containing perfluoroalkanetriyl groups having from 6 to about 15 carbon atoms, and perfluorocycloalkanetriyl groups having from 3 to about 12 carbon atoms; each R<sub>h</sub> is independently selected from the group consisting of linear or branched alkyl groups having from 1 to about 8 carbon atoms, cycloalkyl-containing alkyl groups having from 4 to about 8 carbon atoms, and cycloalkyl groups having from 3 to about 8 carbon atoms; wherein either or both of the groups R<sub>f</sub> and R<sub>h</sub> can contain one or more catenary heteroatoms; and wherein the sum of the number of carbon atoms in R<sub>f</sub> and the number of carbon atoms in R<sub>h</sub> is greater than or equal to 4.

25

4. The process of Claim 3 wherein x is 1; R<sub>h</sub> is an alkyl group having from 1 to about 6 carbon atoms; and R<sub>f</sub> but not R<sub>h</sub> can contain one or more catenary heteroatoms.

5. The process of Claim 4 wherein R<sub>f</sub> is selected from the group consisting of linear or branched perfluoroalkyl groups having from 3 to about 6 carbon atoms, perfluorocycloalkyl-containing

5 perfluoroalkyl groups having from 5 to about 8 carbon atoms, and perfluorocycloalkyl groups having from 5 to about 6 carbon atoms; and R<sub>h</sub> is an alkyl group having from 1 to about 3 carbon atoms.

10 6. The process of claim 1, wherein the cleaning composition further comprises surfactant.

7. The process of claim 6, wherein the surfactant comprises a nonionic surfactant chosen from

15 the group consisting of an ethoxylated alcohol, an ethoxylated alkylphenol, an ethoxylated fatty acid, an alkylaryl sulfonate, a glycerol ester, an ethoxylated fluoroalcohol, a fluorinated sulfonamide, and mixtures thereof.

20 8. The process of claim 6, wherein the cleaning composition comprises from about 0.1 to about 5 percent by weight surfactant.

9. A dry cleaning process for removing  
contaminants from the surface of a fabric substrate,  
the process comprising the step of contacting a fabric  
substrate with a liquid- and/or vapor-phase cleaning  
5 composition comprising at least one compound selected  
from the group consisting of  $c\text{-C}_6\text{F}_{11}\text{CF}_2\text{OC}_2\text{H}_5$ ,  
 $c\text{-C}_6\text{F}_{11}\text{CF}_2\text{OCH}_3$ ,  $4\text{-CF}_3\text{-c\text{-C}_6\text{F}_{10}\text{CF}_2\text{OCH}_3}$ ,

10  $\begin{array}{c} \text{CF}_2\text{CF}_2 \\ \text{CF}_2 \quad \text{N} \quad (\text{CF}_2)_3\text{OCH}_3 \\ \text{CF}_2\text{CF}_2 \end{array}$ ,  
 $\begin{array}{c} \text{CF}_2\text{CF}_2 \\ \text{F}_2 \quad \text{N} \quad (\text{CF}_2)_2\text{OC}_2\text{H}_5 \\ \text{CF}_2\text{CF}_2 \end{array}$ ,  
 $\begin{array}{c} \text{CF}_2\text{CF}_2 \\ \text{O} \quad \text{N} \quad (\text{CF}_2)_3\text{OCH}_3 \\ \text{CF}_2\text{CF}_2 \end{array}$ ,  $\text{CH}_3\text{OCF}_2\text{-c\text{-C}_6\text{F}_{10}\text{CF}_2\text{OCH}_3$ ,  $\text{C}_4\text{F}_9\text{OC}_2\text{H}_5$ ,  
 $\text{C}_4\text{F}_9\text{OCH}_3$ ,  $\text{c\text{-C}_6\text{F}_{11}\text{OCH}_3$ ,  $(\text{CF}_3)_2\text{CFCF}_2\text{OCH}_3$ ,  $(\text{CF}_3)_2\text{CFCF}_2\text{OC}_2\text{H}_5$ ,  
 $\text{C}_8\text{F}_{17}\text{OCH}_3$ ,  $\text{C}_2\text{F}_5\text{CF}(\text{OCH}_3)\text{CF}(\text{CF}_3)_2$ ,  $\text{CF}_3\text{CF}(\text{OCH}_3)\text{CF}(\text{CF}_3)_2$ ,  
 $\text{C}_5\text{F}_{11}\text{OCH}_3$ ,  $\text{C}_5\text{F}_{11}\text{OC}_2\text{H}_5$ , and  $\text{C}_3\text{F}_7\text{OCH}_3$ .

15

10. The process of claim 9, wherein the  
cleaning composition further comprises surfactant.

11. The process of claim 10, wherein the  
20 surfactant comprises a nonionic surfactant chosen from  
the group consisting of an ethoxylated alcohol, an  
ethoxylated alkylphenol, an ethoxylated fatty acid, an  
alkylaryl sulfonate, a glycerol ester, an ethoxylated  
fluoroalcohol, a fluorinated sulfonamide, and mixtures  
25 thereof.

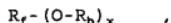
12. The process of claim 10, wherein the cleaning composition comprises from about 0.1 to about 5 percent by weight surfactant.

5

13. A cleaning composition comprising (a) a major amount of at least one mono-, di-, or trialkoxy-substituted perfluoroalkane, perfluorocycloalkane, perfluorocycloalkyl-containing perfluoroalkane, or 10 perfluorocycloalkylene-containing perfluoroalkane compound, said compound optionally containing one or more additional catenary heteroatoms; and (b) surfactant.

15 14. The composition of Claim 13, wherein said compound has a boiling point in the range of from about 25°C to about 200°C.

15. The composition of Claim 13, wherein said 20 compound is represented by the general formula



wherein x is an integer of 1 to 3; when x is 1, R<sub>f</sub> is 25 selected from the group consisting of linear or branched perfluoroalkyl groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl-containing perfluoroalkyl groups having from 5 to about 15 carbon atoms, and perfluorocycloalkyl groups having from 3 to 30 about 12 carbon atoms; when x is 2, R<sub>f</sub> is selected from

the group consisting of linear or branched perfluoroalkanediyl groups or perfluoroalkylidene groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-  
5 containing perfluoroalkanediyl or perfluoroalkylidene groups having from 6 to about 15 carbon atoms, and perfluorocycloalkanediyl groups or perfluorocycloalkylidene groups having from 3 to about 12 carbon atoms; when x is 3, R<sub>f</sub> is selected from the  
10 group consisting of linear or branched perfluoroalkanetriyl groups having from 2 to about 15 carbon atoms, perfluorocycloalkyl- or perfluorocycloalkylene-containing perfluoroalkanetriyl groups having from 6 to about 15 carbon atoms, and  
15 perfluorocycloalkanetriyl groups having from 3 to about 12 carbon atoms; each R<sub>h</sub> is independently selected from the group consisting of linear or branched alkyl groups having from 1 to about 8 carbon atoms, cycloalkyl-containing alkyl groups having from 4 to about 8 carbon  
20 atoms, and cycloalkyl groups having from 3 to about 8 carbon atoms; wherein either or both of the groups R<sub>f</sub> and R<sub>h</sub> can contain one or more catenary heteroatoms; and wherein the sum of the number of carbon atoms in R<sub>f</sub> and the number of carbon atoms in R<sub>h</sub> is greater than or  
25 equal to 4.

16. The composition of claim 13, wherein the surfactant comprises a nonionic surfactant.

17. The composition of claim 16, wherein the nonionic surfactant is selected from the group consisting of an ethoxylated alcohol, an ethoxylated alkylphenol, an ethoxylated fatty acids, an alkylaryl 5 sulfonate, a glycerol ester, an ethoxylated fluoroalcohol, a fluorinated sulfonamide, and mixtures thereof.

18. The composition of claim 13, wherein the 10 composition comprises from about 0.1 to about 5 percent by weight surfactant.

19. A composition comprising (a) a major amount of at least one compound selected from the group 15 consisting of  
 $c-C_6F_{11}CF_2OC_2H_5$ ,  $c-C_6F_{11}CF_2OCH_3$ ,  $4-CF_3-c-C_6F_{10}CF_2OCH_3$ ,

$CF_2CF_2$   
 $CF_2N(CF_2)_3OCH_3$   
 $CF_2CF_2$ ,  
 $CF_2CF_2$   
 $F_2N(CF_2)_2OC_2H_5$   
 $CF_2CF_2$ ,  
 $CF_2CF_2$   
 $O_N(CF_2)_3OCH_3$   
20  $CF_2CF_2$ ,  $CH_3OCF_2-c-C_6F_{10}CF_2OCH_3$ ,  $C_4F_9OC_2H_5$ ,  
 $C_4F_9OCH_3$ ,  $c-C_6F_{11}OCH_3$ ,  $(CF_3)_2CFCF_2OCH_3$ ,  $(CF_3)_2CFCF_2OC_2H_5$ ,  
 $C_8F_{17}OCH_3$ ,  $C_2F_5CF(OCH_3)CF(CF_3)_2$ ,  $CF_3CF(OCH_3)CF(CF_3)_2$ ,  
 $C_5F_{11}OCH_3$ ,  $C_5F_{11}OC_2H_5$ , and  $C_3F_7OCH_3$ ; and (b) surfactant.

20. The composition of claim 19, wherein the surfactant comprises a nonionic surfactant.

21. The composition of claim 20, wherein the 5 nonionic surfactant is selected from the group consisting of an ethoxylated alcohol, an ethoxylated alkylphenol, an ethoxylated fatty acids, an alkylaryl sulfonate, a glycerol ester, an ethoxylated fluoroalcohol, a fluorinated sulfonamide, and mixtures 10 thereof.

22. The composition of claim 19, wherein the composition comprises from about 0.1 to about 5 percent by weight surfactant.

15  
23. A process for removing contaminants from a substrate comprising the steps of contacting a substrate with a liquid- and/or vapor-phase cleaning composition comprising (a) at least one mono-, di-, or 20 trialkyloxy-substituted perfluoroalkane, perfluorocycloalkane, perfluorocycloalkyl-containing perfluoroalkane, or perfluorocycloalkylene-containing perfluoroalkane compound, said compound optionally containing one or more additional catenary heteroatoms; 25 and (b) surfactant.

## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 96/07157A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C11D7/50 D06L1/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 C11D C07D C07C D06L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	DATABASE WPI Section Ch, Week 9650 Derwent Publications Ltd., London, GB; Class D25, AN 96-503018 XP002029482 & JP 08 259 995 A (AGENCY OF IND SCI & TECHNOLOGY) , 8 October 1996 see abstract ---	1-5,23
A	EP 0 450 855 A (ICI PLC) 9 October 1991 cited in the application see claims ---	1,2,23
A	WO 93 09272 A (ALLIED SIGNAL INC) 13 May 1993 see page 16, line 20 - page 17, line 14; claims ---	1,2,23

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

## \* Special categories of cited documents :

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- "O" document referring to an oral disclosure, use, exhibition or sale made prior to the international filing date
- "P" documents published prior to the international filing date but later than the priority date claimed

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- "X" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "A" document member of the same patent family

1 Date of the actual completion of the international search  15 April 1997	Date of mailing of the international search report  23.04.97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-3040, Tx. 31 651 epo nl, Fax. (+31-70) 340-3016	Authorized officer  Grittern, A

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 96/07157

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 854 871 A (EANZEL A) 17 December 1974 see claims ---	1,2,23
A	DATABASE WPI Section Ch, Week 9117 Derwent Publications Ltd., London, GB; Class B03, AN 91-123600 XP002003769 & SU 1 427 780 A (NOVOS ORG CHEM INST) , 15 September 1990 see abstract -----	

## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 96/07157

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205 6039766 (attached)

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(12) 公開特許公報 (A)

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(21) 出願番号	特願平9-304438	(71) 出願人	000226161 日華化学株式会社 福井県福井市文京4丁目23番1号
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(54) 【発明の名称】 ドライクリーニング用洗浄剤組成物

(57) 【要約】

【課題】ドライクリーニング用洗浄剤に要求される洗浄性などの性能を損なうことなく、再汚染防止性や帯電防止性及び柔軟性などに優れ、第三世代のフロン系溶剤に添加して使用することができるドライクリーニング用洗浄剤組成物を提供する。

【解決手段】フッ素系ポリオキシアルキレンアルキルエーテルリン酸エステル、フッ素系ポリオキシアルキレンアルキルスルホンアミドエーテルリン酸エステル、フッ素系アルキルスルホンアミドカルボン酸、フッ素系アルキカルボン酸、フッ素系アルキルスルホン酸及びフッ素系リン酸エステルから選ばれる少なくとも1種のフッ素系化合物の塩からなるフッ素系界面活性剤1～90重量%並びに化炭化水素系溶剤及び/又は溶解助剤10～99重量%を含有することを特徴とするドライクリーニング用洗浄剤組成物。

## 【特許請求の範囲】

【請求項1】 フッ素系界面活性剤並びにフッ化炭化水素系溶剤及び／又は溶解助剤を含有するドライクリーニング用洗浄剤組成物において、フッ素系界面活性剤が、一般式【1】で表されるフッ素系ポリオキシアルキレンアルキルエーテルリン酸エステル、一般式【2】で表されるフッ素系ポリオキシアルキレンアルキルスルホンアミドエーテルリン酸エステル、一般式【3】で表されるフッ素系アルキルスルホンアミドカルボン酸、一般式

$$[R^1CH_2CH_2O(R^2O)_p]_pPO(OH)_{3-p} \cdots [1]$$
  
(ただし、式中、R<sup>1</sup>は炭素数3～12のパーフロロアルキル基であり、R<sup>2</sup>は炭素数2～4のアルキレン基で

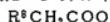


(ただし、式中、R<sup>3</sup>は炭素数3～12のパーフロロアルキル基であり、R<sup>4</sup>は炭素数1～5のアルキル基であり、R<sup>5</sup>は炭素数2～4のアルキレン基であり、qは0



… [3]

(ただし、式中、R<sup>6</sup>は炭素数3～12のパーフロロアルキル基であり、R<sup>7</sup>は炭素数1～5のアルキル基であ



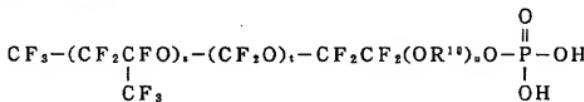
… [4]

(ただし、式中、R<sup>8</sup>は炭素数3～12のパーフロロアルキル基である。)



… [5]

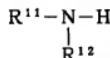
(ただし、式中、R<sup>9</sup>は炭素数6～12のパーフロロアルキル基である。)



… [6]

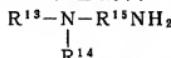
(ただし、式中、R<sup>10</sup>は炭素数2～4のアルキレン基であり、sは1～10であり、tは0～1であり、uは1～10である。)

【請求項2】 フッ素系界面活性剤が、一般式【7】で表されるアミン、一般式【8】で表されるジアミン、一般



… [7]

(ただし、式中、R<sup>11</sup>及びR<sup>12</sup>は水素、炭素数1～12のアルキル基、シクロヘキシル基、ベンジル基又は炭素数1～4のヒドロキシアルキル基であり、R<sup>11</sup>とR<sup>12</sup>は



… [8]

(ただし、式中、R<sup>13</sup>及びR<sup>14</sup>は水素又は炭素数1～6のアルキル基であり、R<sup>13</sup>とR<sup>14</sup>は同一でも異なってい

【4】で表されるフッ素系アルキルカルボン酸、一般式【5】で表されるフッ素系アルキルスルホン酸及び一般式【6】で表されるフッ素系リン酸エチルから選ばれる少なくとも1種のフッ素系化合物の塩であり、かつ、フッ素系界面活性剤の含有量が1～90重量%であり、フッ化炭化水素系溶剤及び／又は溶解助剤の含有量が10～99重量%であることを特徴とするドライクリーニング用洗浄剤組成物。

$$[R^1CH_2CH_2O(R^2O)_p]_pPO(OH)_{3-p} \cdots [1]$$

(ただし、式中、R<sup>1</sup>は炭素数3～12のパーフロロアルキル基であり、R<sup>2</sup>は炭素数2～4のアルキレン基で

【化1】

～10であり、rは1～2である。)

【化2】

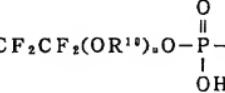
る。)

… [4]

ルキル基である。)

… [5]

【化3】



式【9】で表されるトリアミン、一般式【10】で表されるアルコキシアルキルアミン又はこれらの化合物のアルキレンオキサイド付加物の塩である請求項1記載のドライクリーニング用洗浄剤組成物。

【化4】

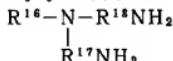
… [7]

同一でも、異なっていてもよい。)

【化5】

てもよく、R<sup>15</sup>は炭素数1～10のアルキレン基、 $-C_2H_4OC_2H_4-$ 、 $-C_2H_4OC_2H_4OC_2H_4-$ 、 $-C_3$

$H_6OCH_2C(CH_3)_2CH_2OC_3H_6$  - 又は  $-C_3H_6O$   
 $C_2H_4(OC_2H_4)_kOC_3H_6$  - であり、kは0~5である



(ただし、式中、 $R^{16}$ は水素又は炭素数1~4のアルキル基であり、 $R^{17}$ 及び $R^{18}$ は炭素数2~6のアルキレン基であり、 $R^{19}$ は炭素数1~14のアルキル基であり、 $R^{20}$ は炭素数2~6のアルキレン基である。)

【請求項3】 フッ化炭化水素系溶剤が、一般式【11】で表されるアルコキシバーフロアルカン及び/又は



(ただし、式中、nは3~4であり、mは1~3である



【請求項4】 溶解助剤が、アルコール系溶剤、アルコールのアルキレンオキサイド付加物からなるエーテル系溶剤、グリコール系溶剤、炭化水素系溶剤、ケトン系溶剤から選ばれる1種又は2種以上の混合物である請求項1、請求項2又は請求項3記載のドライクリーニング用洗浄剤組成物。

【発明の詳細な説明】

#### 【00001】

【発明の属する技術分野】 本発明は、ドライクリーニング用洗浄剤組成物に関する。さらに詳しくは、本発明は、洗浄性と再汚染防止性に優れ、被洗物に帯電防止性と柔軟性を与えることができるドライクリーニング用洗浄剤組成物に関する。

#### 【00002】

【従来の技術】 衣類などの洗濯には、水を用いる中性洗濯のウエットクリーニング、アルカリ性洗濯のランドリークリーニング、石油系溶剤、バーコロエチレン、 $HCFC-113$ 、 $1,1,1$ -トリクロロエタン、代替フロン溶剤などを用いるドライクリーニングがある。1995年未満をもってトリクロロエタン、特定フロンの生産が中止され、代替フロン溶剤として、 $HCFC-225$ 、 $HCFC-141b$ などの溶剤が、ドライクリーニング用溶剤として使用されている。しかしながら、これらの溶剤は、沸点が低く、乾燥は容易で速く、衣類に対する乾燥時の機械的損傷は比較的小さいものの、オゾン破壊係数、地球温暖化係数が大きく、使用可能な期間が限定されている。また、 $HCFC-225$ には、アクリル樹脂などを損傷するケミカルアタックがある。特開平6-158531号公報には、化学的な障害を被洗物に与えることなく汚れを除去することができる洗濯方法として、 $FC-51-14$ 、 $FC-61-16$ 、 $FC-71-18$ などのフッ化炭素液体類に、フッ素系界面活性剤を添加した液体を洗浄液として使用する洗濯方法が提案されている。しかし、このようなフッ化炭素液体類は洗浄力が弱く、フッ素系界面活性剤を添加しても、満足す

る。)

#### 【化6】

… [9]

基であり、 $R^{17}$ と $R^{18}$ は同一でも異なっていてもよい。)

… [10]

般式【12】で表されるオクタフロロシクロヘキサンである請求項1又は請求項2記載のドライクリーニング用洗浄剤組成物。

… [11]

る。)

… [12]

べき洗浄性を得ることは困難である。従来のドライクリーニング用洗浄剤組成物は、炭化水素を親油基とするカチオン系界面活性剤若しくはアニオン系界面活性剤及びノニオン系界面活性剤を主成分とし、洗浄性や再汚染防止性、帯電防止性、柔軟性、抗菌性などの性能を有していて、さらに新規な界面活性剤を使用する必要はなかった。近年、オゾン破壊係数と地球温暖化係数が小さいフッ化炭化水素系のいわゆる第三世代フロン系溶剤が、 $HCFC$ 系溶剤を代替する溶剤として、金属部品、電子部材の洗浄などで使用され始めており、ドライクリーニング用代替フロン溶剤としても使用が予定されている。しかし、これらの第三世代フロン系溶剤は、従来のドライクリーニング用溶剤に比較してK B値(カウリブタノール値)がかなり小さく、溶解力が極めて弱いために、従来ドライクリーニング用洗浄剤組成物に使用されてきた炭化水素系界面活性剤を用いることができない。このため、洗浄性と再汚染防止性に優れ、しかも被洗物に帯電防止性と柔軟性を与える、第三世代の代替フロン溶剤に添加して使用することができるドライクリーニング用洗浄剤組成物が求められている。

#### 【00003】

【発明が解決しようとする課題】 本発明は、ドライクリーニング用洗浄剤に要求される洗浄性などの性能を損なうことなく、再汚染防止性や帯電防止性及び柔軟性などに優れ、第三世代のフロン系溶剤に添加して使用することができるドライクリーニング用洗浄剤組成物を提供することを目的としてなされたものである。

#### 【00004】

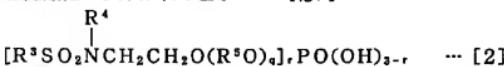
【課題を解決するための手段】 本発明者らは、上記の課題を解決すべく観察研究を重ねた結果、特定構造を有するフッ素系界面活性剤とフッ化炭化水素系溶剤及び/又は溶解放剤を含有するドライクリーニング用洗浄剤組成物が、K B値が低い第三世代のフロン系溶剤であるメチルバーフロロブチルエーテル、エチルバーフロロブチルエーテルなどのアルコキシバーフロアルカン及びオク

タフロシクロベンタンなどのフロン系溶剤に可溶であり、優れた洗浄性、再汚染防止性、電気防止性、柔軟性などを発揮することを見いだし、この知見に基づいて本発明を完成するに至った。すなわち、本発明は、(1) フッ素系界面活性剤並びにフッ化炭化水素系溶剤及び/又は溶解助剤を含有するドライクリーニング用洗浄剤組成物において、フッ素系界面活性剤が、一般式【1】で表されるフッ素系ポリオキシアルキレンアルキルエーテルリン酸エステル、一般式【2】で表されるフッ素系ポリオキシアルキレンアルキルスルホニアミドエーテルリ

[R<sup>1</sup>CH<sub>2</sub>CH<sub>2</sub>O(R<sup>2</sup>O)<sub>p</sub>]<sub>q</sub>PO(OH)<sub>3-p</sub> … [1]  
(ただし、式中、R<sup>1</sup>は炭素数3～12のバーフロロアルキル基であり、R<sup>2</sup>は炭素数2～4のアルキレン基で

あり、qは0～10であり、pは1～2である。)

【化7】



(ただし、式中、R<sup>3</sup>は炭素数3～12のバーフロロアルキル基であり、R<sup>4</sup>は炭素数1～5のアルキル基であり、R<sup>5</sup>は炭素数2～4のアルキレン基であり、qは0



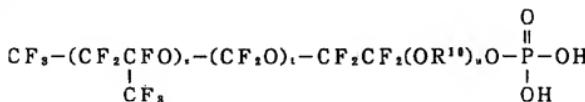
(ただし、式中、R<sup>6</sup>は炭素数3～12のバーフロロアルキル基であり、R<sup>7</sup>は炭素数1～5のアルキル基であ

R<sup>8</sup>CH<sub>2</sub>COOH … [4]

(ただし、式中、R<sup>8</sup>は炭素数3～12のバーフロロアルキル基である。)

R<sup>9</sup>SO<sub>2</sub>H … [5]

(ただし、式中、R<sup>9</sup>は炭素数6～12のバーフロロアルキル基である。)



… [6]

(ただし、式中、R<sup>10</sup>は炭素数2～4のアルキレン基であり、sは1～10であり、tは0～1であり、uは1～10である。)、(2) フッ素系界面活性剤が、一般式【7】で表されるアミン、一般式【8】で表されるジアミン、一般式【9】で表されるトリアミン、一般式



(ただし、式中、R<sup>11</sup>及びR<sup>12</sup>は水素、炭素数1～12のアルキル基、シクロヘキシル基、ベンジル基又は炭素数1～4のヒドロキシアルキル基であり、R<sup>11</sup>とR<sup>12</sup>は

同一でも、異なっていてもよい。)

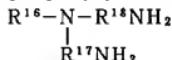
【化11】



(ただし、式中、R<sup>13</sup>及びR<sup>14</sup>は水素又は炭素数1～6

のアルキル基であり、R<sup>13</sup>とR<sup>14</sup>は同一でも異なってい

てもよく、R<sup>16</sup>は炭素数1～10のアルキレン基、-C<sub>2</sub>H<sub>4</sub>OCH<sub>2</sub>H<sub>4</sub>-、-C<sub>2</sub>H<sub>4</sub>OCH<sub>2</sub>H<sub>4</sub>OCH<sub>2</sub>H<sub>4</sub>-、-C<sub>3</sub>H<sub>6</sub>OCH<sub>2</sub>C(CH<sub>3</sub>)<sub>2</sub>CH<sub>2</sub>OCH<sub>2</sub>H<sub>6</sub>-又は-C<sub>3</sub>H<sub>6</sub>O



(ただし、式中、R<sup>16</sup>は水素又は炭素数1～4のアルキル基であり、R<sup>17</sup>及びR<sup>18</sup>は炭素数2～6のアルキレン基であり、R<sup>19</sup>及F<sup>20</sup>は炭素数1～4のアルキレン基である。)

(ただし、式中、R<sup>19</sup>は炭素数1～14のアルキル基であり、R<sup>20</sup>は炭素数2～6のアルキレン基である。)、  
(3) フッ化炭化水素系溶剤が、一般式[11]で表されるアルコキシバーフロアルカン及び/又は一般式



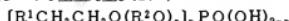
(ただし、式中、nは3～4であり、mは1～3である。)



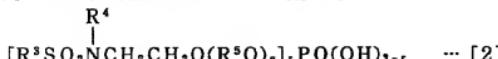
及び、(4) 溶解助剤が、アルコール系溶剤、アルコールのアルキレンオキサイド付加物からなるエーテル系溶剤、グリコール系溶剤、炭化水素系溶剤、ケトン系溶剤から選ばれる1種又は2種以上の混合物である第(1)項、第(2)項又は第(3)項記載のドライクリーニング用洗浄剤組成物、を提供するものである。

【0005】

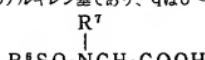
【発明の実施の形態】本発明のドライクリーニング用洗浄剤組成物は、ドライクリーニング用溶剤に添加溶解して用いることができる。本発明組成物は、ドライクリーニング用溶剤として第三世代のフロン系溶剤を使用する場合には特に有用である。本発明組成物は、フッ素系界面活性剤1～90重量%及び/又はフッ化炭化水素系溶剤及び/又は溶解助剤1～90重量%を含有し、より好ましくは、フッ素系界面活性剤5～70重量%及び/又はフッ



ただし、一般式[1]において、R<sup>1</sup>は炭素数3～12、より好ましくは炭素数6～8のバーフロアルキル基であり、R<sup>2</sup>は炭素数2～4、より好ましくは炭素数2～3のアルキレン基であり、pは0～10、より好ましくは1～5であり、pは1～2、より好ましくは1～



ただし、一般式[2]において、R<sup>3</sup>は炭素数3～12、より好ましくは炭素数6～8のバーフロアルキル基であり、R<sup>4</sup>は炭素数1～5、より好ましくは炭素数1～3のアルキレン基であり、R<sup>5</sup>は炭素数2～4、より好ましくは2～3のアルキレン基であり、qは0～1



ただし、一般式[3]において、R<sup>6</sup>は炭素数3～12、より好ましくは炭素数6～8のバーフロアルキル

C<sub>2</sub>H<sub>4</sub>(OC<sub>2</sub>H<sub>4</sub>)<sub>k</sub>OC<sub>2</sub>H<sub>6</sub>-であり、kは0～5である。)

【化12】

… [9]

基であり、R<sup>17</sup>とR<sup>18</sup>は同一でも異なっていてもよい。)

… [10]

[12]で表されるオクタフロロシクロヘキサンである。請求項1又は請求項2記載のドライクリーニング用洗浄剤組成物、

… [11]

る。)

… [12]

化炭化水素溶剤及び/又は溶解助剤30～95重量%を含有する。本発明組成物において、フッ素系界面活性剤の含有量が1重量%未満であると、洗浄力、帯電防止性、柔軟性が十分に発現しないおそれがある。フッ素系界面活性剤の含有量が90重量%を超えると、ドライクリーニング用洗浄剤組成物の粘度、安定性、使い易さに難点が生ずるおそれがある。

【0006】本発明のドライクリーニング用洗浄剤組成物において、フッ素系界面活性剤は、一般式[1]～[6]で表される構造を有するリン酸エステル、カルボン酸及びスルホン酸から選ばれる少なくとも1種のフッ素系化合物の塩である。

(1) 一般式[1]で表されるフッ素系ポリオキシアルキレンアルキルエーテルリン酸エステル、

… [1]

ある。

【0007】(2) 一般式[2]で表されるフッ素系ポリオキシアルキレンアルキルスルホンアミドエーテルリン酸エステル、

【化13】

0、より好ましくは1～5であり、rは1～2、より好ましくは1である。

(3) 一般式[3]で表されるフッ素系アルキルスルホンアミドカルボン酸、  
【化14】

… [3]

基であり、R<sup>7</sup>は炭素数1～5、より好ましくは炭素数1～3のアルキレン基である。

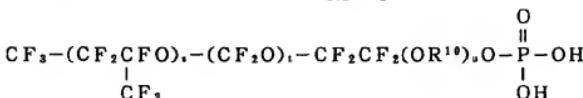
(4) 一般式 [4] で表されるフッ素系アルキルカルボ



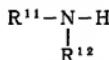
ただし、一般式 [4] において、R<sup>8</sup>は炭素数3～12、より好ましくは炭素数6～10のバーフロアルキル基である。



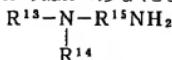
ただし、一般式 [5] において、R<sup>9</sup>は炭素数6～12、より好ましくは炭素数6～8のバーフロアルキル基である。及び、



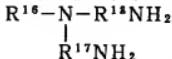
ただし、一般式 [6] において、R<sup>10</sup>は炭素数2～4、より好ましくは炭素数2～3のアルキレン基であり、sは1～10、より好ましくは3～6であり、tは0～1であり、uは1～10、より好ましくは3～5である。  
【0009】本発明のドライクリーニング用洗浄剤組成



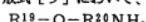
ただし、一般式 [7] において、R<sup>11</sup>及びR<sup>12</sup>は水素、炭素数1～12のアルキル基、シクロヘキシル基、ベンジル基又は炭素数1～4のヒドロキシアルキル基であり、R<sup>11</sup>とR<sup>12</sup>は同一でも、異なっていてもよい。一般式 [7] において、R<sup>11</sup>又はR<sup>12</sup>の少なくとも一方が、



ただし、一般式 [8] において、R<sup>13</sup>及びR<sup>14</sup>は水素又は炭素数1～6のアルキル基であり、R<sup>13</sup>とR<sup>14</sup>は同一でも異なっていてもよく、R<sup>15</sup>は炭素数1～10のアルキレン基、-C<sub>2</sub>H<sub>4</sub>OC<sub>2</sub>H<sub>4</sub>-、-C<sub>2</sub>H<sub>4</sub>OC<sub>2</sub>H<sub>4</sub>OC<sub>2</sub>H<sub>4</sub>-、-C<sub>8</sub>H<sub>6</sub>OC<sub>2</sub>H<sub>4</sub>(CH<sub>3</sub>)<sub>2</sub>CH<sub>2</sub>OC<sub>8</sub>H<sub>6</sub>-又は-C<sub>8</sub>H<sub>6</sub>OC<sub>2</sub>H<sub>4</sub>(OC<sub>2</sub>H<sub>4</sub>)<sub>3</sub>OC<sub>8</sub>H<sub>6</sub>-である、k



ただし、一般式 [9] において、R<sup>16</sup>は水素又は炭素数1～4のアルキル基であり、R<sup>17</sup>及びR<sup>18</sup>は炭素数2～6のアルキレン基であり、R<sup>17</sup>とR<sup>18</sup>は同一であっても、異なっていてもよい。一般式 [9] において、R<sup>16</sup>



ただし、一般式 [10] において、R<sup>19</sup>は炭素数1～14のアルキル基であり、R<sup>20</sup>は炭素数2～6のアルキレン基である。一般式 [10] において、R<sup>20</sup>が炭素数2～4のアルキレン基であることがより好ましい。

【0011】一般式 [1] ～ [6] で表されるフッ素系

ン酸、

… [4]

【0008】 (5) 一般式 [5] で表されるフッ素系アルキルスルホン酸、

… [5]

(6) 一般式 [6] で表されるフッ素系リン酸エステル、

【化15】



… [6]

物においては、フッ素系界面活性剤が、一般式 [7] ～ [10] で表されるアミン又はこれらの化合物のアルキレンオキサイド付加物の塩であることが好ましい。

(7) 一般式 [7] で表されるアミン、

【化16】

… [7]

炭素数1～10のアルキル基、シクロヘキシル基、ベンジル基又は炭素数2～3のヒドロキシアルキル基であることがより好ましい。

(8) 一般式 [8] で表されるジアミン、

【化17】

… [8]

は0～5である。一般式 [8] において、R<sup>13</sup>及びR<sup>14</sup>が水素又は炭素数1～2のアルキル基であることがより好ましい。

【0010】 (9) 一般式 [9] で表されるトリアミン、

【化18】

… [9]

が水素又は炭素数1～2のアルキル基であることがより好ましい。及び、

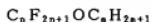
(10) 一般式 [10] で表されるアルコキシアルキルアミン、

… [10]

のリン酸エステル、カルボン酸及びスルホン酸から選ばれる化合物と、一般式 [7] ～ [10] で表されるアミン又はそれらのアルキレンオキサイド付加物の塩からなるフッ素系界面活性剤を用いることにより、ドライクリーニング用洗浄剤組成物の洗浄性と再汚染防止性を高

め、被洗物に優れた帯電防止性と柔軟性を与えることが可能となるとともに、ドライクリーニング用洗浄剤組成物のドライクリーニング用溶剤に対する溶解性を高め、臭気を抑えることができる。

【0012】本発明のドライクリーニング用洗浄剤組成



ただし、一般式【11】において、nは3~4であり、



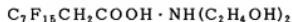
本発明のドライクリーニング用洗浄剤組成物においては、溶解助剤が、メタノール、エタノール、イソアロパノールなどのアルコール系溶剤、アルコールのアルキレンオキサイド付加物からなるエーテル系溶剤、グリコール系溶剤、炭化水素系溶剤又はケトン系溶剤であることが好ましい。これらの溶解助剤は、1種を単独で使用することができ、あるいは2種以上を混合して使用することができる。本発明組成物において、溶解助剤を含有せしめることにより、ドライクリーニング用洗浄剤組成物の粘度を下げ、安定性を向上することができる。溶解助剤の中では、毒性が低く、引火点が比較的高い3-メチル-3-メトキシブタノール特に好適に用いることができる。本発明のドライクリーニング用洗浄剤組成物においては、必要に応じて、さらにはボリオキシプロピレン(7モル)バーフロアルキルエーテル、ボリオキシエチレン(2モル)ノニルフェニルエーテル、ボリオキシエチレン(3モル)ラウリルエーテルなどのノニオン界面活性剤、シリコーンオイル、防錆剤などを適宜配合することができる。

【0013】

【実施例】以下に、実施例を挙げて本発明をさらに詳細に説明するが、本発明はこれらの実施例によりなんら限定されるものではない。なお、実施例及び比較例において、評価は下記の方法により行った。

(1) 洗浄率及び再汚染率

容量500mlのステンレススポットを用いて、メチルバーフロブチルエーテル(溶剤1)又はエチルバーフロブチルエーテル(溶剤2)100mlに、洗浄剤組成物を0.3容量%添加溶解して洗浄液を調製する。ラウンダ・オ・メーター〔大栄科学精器製作所(株)、L-20〕を用いて、40番綿ブロード、ウールモスリン、アクリルメリヤス及びボリエスルジャージの4cm×8cmの大きさの白布及び日本油化学協会法に準じて作製した4cm×8cmの大きさの汚染布を、洗浄液で20°C×10分間洗浄する。その後、遠心脱水機〔英光産業(株)、H-120A〕を用いて、1分間脱液し、60分間風乾する。洗浄前後の白布及び汚染布について、色彩計〔(株)村上



(2) N-エチルバーフロオクチルスルホニアミド酢酸のオクチルジエタノールアミン塩

物においては、フッ化炭化水素系溶剤が、一般式【11】で表されるアルコキシバーフロアルカン及び/又は一般式【12】で表されるオクタフルオロシクロヘキサンであることが好ましい。

…【11】

mは1~3である。

…【12】

色彩技術研究所、クリーンマスターCM-53D〕を用いて、550nmにおける反射率を測定し、次式にしたがって洗浄率と再汚染率を算出する。

$$\text{洗浄率} (\%) = \{ (S_2 - S_1) / (W_1 - S_1) \} \times 100$$

$$\text{再汚染率} (\%) = \{ (W_1 - W_2) / W_1 \} \times 100$$

ただし、S<sub>1</sub>：洗浄前の汚染布反射率、S<sub>2</sub>：洗浄後の汚染布反射率、W<sub>1</sub>：洗浄前の白布反射率、W<sub>2</sub>：洗浄後の白布反射率である。

(2) 帯電防止性

ドライクリーニング用洗浄剤組成物を、エチルバーフロブチルエーテル10リットルに0.2容量%添加して溶解し、ドライクリーニングテスター〔(株)大栄科学精器製作所、テスターDC-2〕を用いて、着用により汚れた紳士用ズボン(ウール100%品)及び婦人用スカート(ボリエステル100%品)を半分に裁断した試験布を、室温で15分間洗浄する。次いで、遠心脱液機を用いて1分間脱液する。その後、50°Cに保った熱風循環式乾燥機で10分間乾燥し、取り出した直後の表面抵抗を絶縁抵抗計〔東亜電波(株)、SM-8210〕を用いて測定する。

(3) 柔軟性

帯電防止性を評価した後の試験布を室内に1時間放置したのち、触感法により次の5段階で柔軟性を評価する。

1 (粗硬)

2 (やや硬い)

3 (柔らかい)

4 (かなり柔らかい)

5 (非常に柔らかい)

柔らかいほど難の発生が少なく、仕上げ性が良好で、着用感にも優れる。

(4) 洗浄性

柔軟性を評価した後の試験布の汚れ部分を、洗浄前の試験布と目視にて比較する。また、実施例及び比較例において使用した化合物の構造式を、以下に示す。

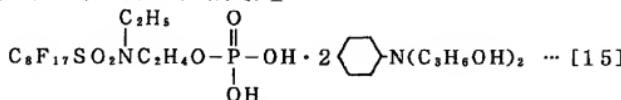
(1) バーフロオクチル酢酸のジエタノールアミン塩

…【13】

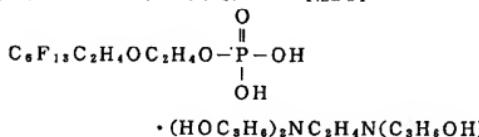
【化19】



(3) N-エチルバーフロロオクチルスルホンアミドエ  
チルリン酸のシクロヘキシルジプロパンオールアミン塩  
【化20】



(4) 2-バーフロヘキシルエトキシエチルリン酸の  
N,N,N',N'-テトラプロパンオールエチレンジアミン  
【化21】

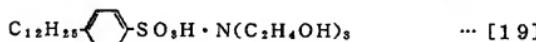


(5) ポリオキシプロピレン(7モル)-2-バーフロヘキシルエチルエーテル  
 $\text{C}_6\text{F}_{13}\text{C}_2\text{H}_4\text{O}(\text{C}_3\text{H}_6\text{O})_7\text{H} \cdots [17]$

(6) ポリオキシエチレン(3モル)ラウリルエーテル  
 $\text{C}_{13}\text{H}_{25}\text{O}(\text{C}_2\text{H}_4\text{O})_3\text{H} \cdots [18]$

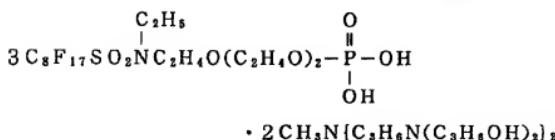
(7) ドデシルベンゼンスルホン酸のトリエタノールアミン塩

【化22】



(8) N-エチルバーフロオクチルスルホンアミドエトキシエチルリ  
ン酸のメチルビス(ジヒドロキシプロピルアミノメチル)アミン塩

【化23】



#### 実施例1

式[13]で表されるペンタデカフロロカブリル酸のジ  
エタノールアミン塩10重量部、3-メチル-3-メト  
キシブタノール50重量部及びエチルバーフロプロチル  
エーテル40重量部を混合して、ドライクリーニング用  
洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行  
った。溶剤1を用いた場合、洗浄率は、綿ブロードが11  
%、ウールモスリンが13%、アクリルメリヤスが6

%、ポリエステルジャージが8%であり、再汚染率は、  
綿ブロードが4.1%、ウールモスリンが4.0%、アクリ  
ルメリヤスが7.3%、ポリエステルジャージが12.2  
%であった。溶剤2を用いた場合、洗浄率は、綿ブロ  
ードが14%、ウールモスリンが2.3%、アクリルメリ  
ヤスが1.0%、ポリエステルジャージが1.1%であり、  
再汚染率は、綿ブロードが5.4%、ウールモスリンが  
5.2%、アクリルメリヤスが10.7%、ポリエステル

ジャージが15.3%であった。

#### 実施例2

式[14]で表されるN-エチルパフロロオキチルスルホンアミド酢酸のオクチルジエタノールアミン塩30重量部及び3-メチル-3-メトキシブタノール30重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行った。溶剤1を用いた場合、洗浄率は、綿ブロードが11%、ウールモスリンが13%、アクリルメリヤスが7%、ポリエステルジャージが7%であり、再汚染率は、綿ブロードが3.7%、ウールモスリンが5.0%、アクリルメリヤスが7.9%、ポリエステルジャージが11.6%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが13%、ウールモスリンが23%、アクリルメリヤスが10%、ポリエステルジャージが10%であり、再汚染率は、綿ブロードが4.9%、ウールモスリンが5.1%、アクリルメリヤスが11.5%、ポリエステルジャージが16.0%であった。

#### 実施例3

式[15]で表されるN-エチルパフロロオキチルスルホンアミドエチルリン酸のシクロヘキシルジプロパノールアミン塩30重量部、3-メチル-3-メトキシブタノール20重量部及びエチルパフロロブチルエーテル50重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行った。溶剤1を用いた場合、洗浄率は、綿ブロードが12%、ウールモスリンが14%、アクリルメリヤスが7%、ポリエステルジャージが7%であり、再汚染率は、綿ブロードが3.8%、ウールモスリンが4.8%、アクリルメリヤスが6.6%、ポリエステルジャージが9.0%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが15%、ウールモスリンが24%、アクリルメリヤスが11%、ポリエステルジャージが11%であり、再汚染率は、綿ブロードが4.0%、ウールモスリンが4.3%、アクリルメリヤスが9.8%、ポリエステルジャージが17.6%であった。

#### 実施例4

式[16]で表される2-パフロロヘキシルエトキシエチルリン酸のN,N,N',N'-テトラアプロパノールエチレンジアミン塩30重量部、3-メチル-3-メトキシブタノール40重量部及びエチルパフロロブチルエーテル30重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行った。溶剤1を用いた場合、洗浄率は、綿ブロードが12%、ウールモスリンが12%、アクリルメリヤスが6%、ポリエステルジャージが7%であり、再汚染率は、綿ブロードが3.5%、ウールモスリンが4.1%、アクリルメリヤスが8.2%、ポリエステルジャージが10.3%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが13%、ウールモスリンが21%、アクリルメリ

ヤスが9%、ポリエステルジャージが9%であり、再汚染率は、綿ブロードが4.5%、ウールモスリンが4.0%、アクリルメリヤスが12.8%、ポリエステルジャージが17.7%であった。

#### 比較例1

式[17]で表されるポリオキシプロピレン(7モル)-2-パフロロヘキシルエチルエーテル50重量部及び3-メチル-3-メトキシブタノール50重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行った。溶剤1を用いた場合、洗浄率は、綿ブロードが9%、ウールモスリンが10%、アクリルメリヤスが4%、ポリエステルジャージが4%であり、再汚染率は、綿ブロードが6.2%、ウールモスリンが6.3%、アクリルメリヤスが10.9%、ポリエステルジャージが17.3%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが12%、ウールモスリンが20%、アクリルメリヤスが8%、ポリエステルジャージが8%であり、再汚染率は、綿ブロードが6.9%、ウールモスリンが5.6%、アクリルメリヤスが17.1%、ポリエステルジャージが24.3%であった。

#### 比較例2

式[18]で表されるポリオキシエチレン(3モル)ラウリルエーテル30重量部及び3-メチル-3-メトキシブタノール70重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を行った。溶剤1を用いた場合、洗浄率は、綿ブロードが8%、ウールモスリンが10%、アクリルメリヤスが5%、ポリエステルジャージが5%であり、再汚染率は、綿ブロードが6.2%、ウールモスリンが5.4%、アクリルメリヤスが10.7%、ポリエステルジャージが16.6%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが11%、ウールモスリンが20%、アクリルメリヤスが7%、ポリエステルジャージが7%であり、再汚染率は、綿ブロードが7.5%、ウールモスリンが6.0%、アクリルメリヤスが16.3%、ポリエステルジャージが23.5%であった。

#### 比較例3

式[19]で表されるデシルベンゼンスルホン酸のトリエタノールアミン塩20重量部、3-メチル-3-メトキシブタノール30重量部及びエチルパフロロブチルエーテル50重量部を混合して、ドライクリーニング用洗浄剤組成物を調製し、洗浄率と再汚染率の評価を試みた。しかし、調製したドライクリーニング用洗浄剤組成物は、溶剤1(メチルパフロロブチルエーテル)にも、溶剤2(エチルパフロロブチルエーテル)にも不溶であり、洗浄試験を行うことができなかった。

#### 比較例4

ドライクリーニング用洗浄剤組成物を添加することなく、溶剤のみを用いて、洗浄率と再汚染率の評価を行つ

た。溶剤1を用いた場合、洗浄率は、綿ブロードが8%、ウールモスリンが9%、アクリルメリヤスが4%、ポリエステルジャージが4%であり、再汚染率は、綿ブロードが6.7%、ウールモスリンが6.1%、アクリルメリヤスが12.5%、ポリエステルジャージが19.3%であった。溶剤2を用いた場合、洗浄率は、綿ブロードが10%、ウールモスリンが19%、アクリルメリヤスが7%、ポリエステルジャージが7%であり、再汚染

率は、綿ブロードが7.1%、ウールモスリンが6.8%、アクリルメリヤスが18.1%、ポリエステルジャージが25.6%であった。実施例1～4及び比較例1～3のドライクリーニング用洗浄剤組成物の配合組成を第1表に、実施例1～4及び比較例1～4の洗浄率及び再汚染率の評価結果を第2表に示す。

## 【0014】

## 【表1】

第1表

		実施例1	実施例2	実施例3	実施例4	比較例1	比較例2	比較例3
配合組成 ～重 量部 ～	式【13】で表される化合物	10	—	—	—	—	—	—
	式【14】で表される化合物	—	70	—	—	—	—	—
	式【15】で表される化合物	—	—	30	—	—	—	—
	式【16】で表される化合物	—	—	—	30	—	—	—
界面活性剤 ～重 量部 ～	式【17】で表される化合物	—	—	—	—	50	—	—
	式【18】で表される化合物	—	—	—	—	—	30	—
	式【19】で表される化合物	—	—	—	—	—	—	20
溶解剤	3-メチル-3-メトキシブタノール	50	30	20	40	50	70	30
フッ化炭化 水素系溶剤	エチルバーフロロブチルエーテル	40	—	50	30	—	—	50

【0015】

第2表

		実施例1	実施例2	実施例3	実施例4	比較例1	比較例2	比較例3	比較例4
溶剤 (%)	綿ブロード	11	11	12	12	9	8	—	8
	ウールモスリン	13	13	14	12	10	10	—	9
	アクリルメリヤス	6	7	7	6	4	5	—	4
	ポリエステルジャージ	8	7	7	7	4	5	—	4
再汚染率 (%)	綿ブロード	4.1	3.7	3.8	3.5	6.2	6.2	—	6.7
	ウールモスリン	4.0	5.0	4.8	4.1	6.3	5.4	—	6.1
	アクリルメリヤス	7.3	7.9	6.6	8.2	10.9	10.7	—	12.5
	ポリエステルジャージ	12.2	11.6	9.0	10.3	17.3	16.6	—	19.3
溶剤 (%)	綿ブロード	14	13	15	13	12	11	—	10
	ウールモスリン	23	23	24	21	20	20	—	19
	アクリルメリヤス	10	10	11	9	8	7	—	7
	ポリエステルジャージ	11	10	11	9	8	7	—	7
再汚染率 (%)	綿ブロード	5.4	4.9	4.0	4.5	6.9	7.5	—	7.1
	ウールモスリン	5.2	5.1	4.3	4.0	5.6	6.0	—	6.8
	アクリルメリヤス	10.7	11.5	9.8	12.8	17.1	16.3	—	18.1
	ポリエステルジャージ	15.3	16.0	17.6	17.7	24.3	23.5	—	25.6

【0016】第2表の結果を、同一繊維素材及び同一溶剤について比較すると、洗浄率は、本発明のドライクリーニング用洗浄剤組成物を用いた実施例の方が、従来のドライクリーニング用洗浄剤組成物を用いた比較例よりも約3%高く、本発明のドライクリーニング用洗浄剤組

成物が、優れた洗浄性を有することが分かる。また、再汚染率は、本発明のドライクリーニング用洗浄剤組成物を用いた実施例の方が、従来のドライクリーニング用洗浄剤組成物を用いた比較例よりも1～8%低く、本発明のドライクリーニング用洗浄剤組成物が、優れた再汚染

防止性を有することが分かる。

実施例5

式〔20〕で表されるN-エチルパーフロオクチルスルホンアミドエキシエトキシエチルリン酸のメチルビス(ジヒドロキシプロピルアミノプロピル)アミン塩30重量部、メチルパーフロオブチルエーテル60重量部及びイソプロピルアルコール10重量部を混合して、ドライクリーニング用洗浄剤組成物を調製した。このドライクリーニング用洗浄剤組成物の帯電防止性は、ズボンについて $4 \times 10^{12} \Omega$ 、スカートについて $2 \times 10^{11} \Omega$ であり、柔軟性は、ズボンについて4、スカートについて4であった。また、洗浄性はズボン、スカートとも、洗浄前の汚れが洗浄後においてはほぼ除去されていた。

比較例5

ボリオキシエチレン(2モル)-2-エチルヘキシルエーテル15重量部、ボリオキシエチレン(2モル)ノニルフェニルエーテル15重量部及びイソプロピルアルコール70重量部を混合して、ドライクリーニング用洗浄剤組成物を調製した。このドライクリーニング用洗浄剤組成物の帯電防止性は、ズボンについて $2 \times 10^{13} \Omega$ 、スカートについて $10^{14} \Omega$ 以上であり、柔軟性は、ズボンについて3、スカートについて3であった。また、洗浄性はズボン、スカートとも、洗浄前の汚れが洗浄後においては多く残留していた。実施例5及び比較例5の結果を、第3表に示す。

【0017】

【表3】

第3表

		実施例5	比較例5
帯電防止性 ( $\Omega$ )	ズボン	$4 \times 10^{12}$	$2 \times 10^{13}$
	スカート	$2 \times 10^{11}$	$> 10^{14}$
柔軟性	ズボン	4	3
	スカート	4	3
洗浄性	ズボン	汚れかほほ 除去されている	汚れの 残留が多い
	スカート	汚れかほほ 除去されている	汚れの 残留が多い

【0018】一般式〔4〕で表されるN-アルキルパーフロアルキルスルホンアミドアルキルボリオキシアルキレンリン酸エステルと一般式〔11〕で表されるトリアミンのプロビレンオキサイド付加物の塩を含有する実

施例5のドライクリーニング用洗浄剤組成物を、エチルパーフロオブチルエーテル溶剤に0.2容量%添加溶解してドライクリーニングに用いたとき、ズボン、スカートともに帯電防止性、柔軟性及び洗浄性に優れている。これに対して、比較例5の炭化水素系洗浄剤組成物は、エチルパーフロオブチルエーテル溶剤に0.2容量%添

加溶解してドライクリーニングに用いたとき、ズボン、スカートともに帯電防止性が劣り、風合いがやや硬い。また洗浄性にも劣っている。

【0019】

【発明の効果】本発明のドライクリーニング用洗浄剤組成物を、第三世代のフロン系溶剤といわれるアルキシバーフロアルカン、オクタフロロシクロヘキサンなどのドライクリーニング溶剤に添加して洗濯することにより、優れた洗浄性と再汚染防止性が得られ、洗濯物に帯電防止性と柔軟性を付与することができる。

フロントページの続き





**United States Patent** [19]  
**Mizuno et al.**

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[45] **Date of Patent:** **Mar. 21, 2000**

[54] **CLEANING PROCESS FOR DRY CLEANING**

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*Primary Examiner*—Alan Diamond  
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[57] **ABSTRACT**

[51] **Int. Cl.7** ..... D06L 1/04; C11D 3/24;

C11D 3/26

[52] **U.S. Cl.** ..... 8/142; 8/137; 510/285;  
510/288; 510/289; 510/175; 134/42; 134/22.19

A process for dry cleaning using a cleaning composition for dry cleaning which includes 1 to 90% by weight of a surfactant containing fluorine and 10 to 99% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent, the surfactant containing fluorine being a salt of a phosphoric acid ester of a polyoxyalkylenealkylsulfonamide ether containing fluorine.

[58] **Field of Search** ..... 8/142, 137; 510/285,  
510/288, 289, 175; 134/42, 22.19

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**4 Claims, No Drawings**

CLEANING PROCESS FOR DRY CLEANING  
BACKGROUND OF THE INVENTION

## 1. Field of the Invention

The present invention relates to a process for dry cleaning of fabrics comprising using a cleaning composition for dry cleaning. More particularly, the present invention relates to a process for dry cleaning comprising using a cleaning composition which shows an excellent cleaning property and property to prevent soiling of cleaned articles and provides a cleaned article with the antistatic property and softness.

## 2. Description of the Related Arts

Cloths and the like can be cleaned by wet cleaning which is a neutral cleaning using water, by laundry cleaning which is an alkaline cleaning, or by dry cleaning using a petroleum solvent, tetrachloroethylene, CFC-113, 1,1,1-trichloroethane, or a fluorine-containing solvent which is used in place of the restricted fluorine-containing solvents. The production of trichloroethane and the restricted fluorine-containing solvents was discontinued at the end of 1995, and solvents such as HCFC-225 and HCFC-141b are used as the solvent for dry cleaning in place of the restricted fluorine-containing solvents.

However, the use of these solvents is allowed within a limited period of time because of high coefficients of ozone-destruction and high coefficients of global warming although these solvents have low boiling points, can be dried rapidly and easily and give a relatively small degree of mechanical damage to cloths during drying. Moreover, HCFC-225 shows chemical attack to give damage to acrylic resins. A method cleaning which can remove soils without chemical damage to articles for cleaning is proposed in Japanese Patent Application Laid-Open No. Heisei 6(1994)-158531, in which a liquid prepared by adding a surfactant containing fluorine to a fluorocarbon liquid such as FC-51-14, FC-61-16 and FC-71-18 is used as the cleaning liquid. However, the fluorocarbon liquids show weak cleaning ability, and it is difficult to obtain satisfactory cleaning ability even when a surfactant containing fluorine is added.

Conventional cleaning compositions for dry cleaning contain a cationic or anionic surfactant having a hydrocarbon group as the lipophilic group and a nonionic surfactant as the main components and have the cleaning property and the property to prevent soiling of cleaned articles and provides cleaned articles with the antistatic property, softness and the antibacterial property. Therefore, it is not necessary that an additional surfactant is used. In recent years, fluorine-containing solvents of the so-called third generation which are fluorohydrocarbons having smaller coefficients of ozone-destruction and smaller coefficients of global warming are being used as the solvent for cleaning metal parts and electronic parts in place of the HCFC solvents. These solvents will be used also as the cleaning solvent for dry cleaning in place of the restricted fluorine-containing solvents. However, the fluorine-containing solvents of the third generation have considerably smaller KB values (kauri-butanol values) and show very small solubilizing ability. Therefore, surfactants having hydrocarbon groups which have heretofore been used in cleaning compositions for dry cleaning cannot be used for the fluorine-containing solvents of the third generation.

A cleaning composition which shows an excellent cleaning property and property to prevent soiling of cleaned articles, provides cleaned articles with the antistatic property and softness and can be used in combination with a fluorine-containing solvent of the third generation has been desired.

## SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a process for dry cleaning comprising the step of dry cleaning using a cleaning composition which does not adversely affect the properties required for a cleaning agent for dry cleaning such as the cleaning property, shows an excellent property to prevent soiling of cleaned articles, provides cleaned articles with the antistatic property and softness and can be used as an additive to fluorine-containing solvents of the third generation.

As the result of extensive studies by the present inventors to solve the above problems, it was found that a cleaning composition comprising a surfactant containing fluorine and having a specific structure and a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent is soluble in fluorine-containing solvents of the third generation having a low KB value, such as alkoxyperfluoroalkanes such as methyl perfluorobutyl ether and ethyl perfluorobutyl ether, and exhibits an excellent cleaning property and property for preventing soiling of cleaned articles and provides cleaned articles with the antistatic property and softness. The present invention was completed on the basis of this knowledge.

Accordingly, the present invention provides:

(1) A process for dry cleaning comprising using a cleaning composition for dry cleaning which comprises 1 to 90% by weight of a surfactant containing fluorine and 10 to 99% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent, wherein the surfactant containing fluorine is a salt of a phosphoric acid ester of a polyoxyalkylenealkylsulfonamide ether containing fluorine which is represented by general formula [1]:



[1]

wherein R<sup>1</sup> represents a perfluoroalkyl group having 3 to 12 carbon atoms, R<sup>2</sup> represents an alkyl group having 1 to 5 carbon atoms, R<sup>3</sup> represents an alkylene group having 2 to 4 carbon atoms, q represents a number of 0 to 10, and r represents a number of 1 or 2;

(2) A process described in (1), wherein the salt of a phosphoric acid ester of a polyoxyalkylenealkylsulfonamide ether containing fluorine is a salt of said ester with a compound represented by general formula [2]:

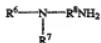


[2]

wherein R<sup>4</sup> and R<sup>5</sup> each represents hydrogen atom, an alkyl group having 1 to 12 carbon atoms, cyclohexyl group, benzyl group, or a hydroxylalkyl group having 1 to 4 carbon atoms, and R<sup>4</sup> and R<sup>5</sup> may be the same with or different from each other;

a diamine represented by general formula [3]:

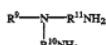
[3]



wherein  $\text{R}^6$  and  $\text{R}^7$  each represents hydrogen atom or an alkyl group having 1 to 6 carbon atoms,  $\text{R}^8$  and  $\text{R}^7$  may be the same with or different from each other, and  $\text{R}^8$  represents an alkylene group having 1 to 10 carbon atoms;

a triamine represented by general formula [4]:

[4]



wherein  $\text{R}^9$  represents hydrogen atom or an alkyl group having 1 to 4 carbon atoms,  $\text{R}^{10}$  and  $\text{R}^{11}$  represents an alkylene group having 2 to 6 carbon atoms, and  $\text{R}^{10}$  and  $\text{R}^{11}$  may be the same with or different from each other; or

an adduct of an alkylene oxide with the amine, the diamine, or the triamine;

(3) A process described in (1) or (2), wherein the fluorohydrocarbon solvent is an alkoxyperfluoroalkane represented by general formula [5]:



[5]

wherein  $n$  represents a number of 3 or 4, and  $m$  represents a number of 1 to 3; and

(4) A process described in (1), (2) or (3), wherein the auxiliary solubilizing agent is a solvent or a mixture of solvents selected from the group consisting of alcohol solvents, ether solvents which are adducts of alkylene oxides with alcohols, glycol solvents, hydrocarbon solvents and ketone solvents.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The cleaning composition for dry cleaning of the present invention is added and dissolved into a solvent for dry cleaning. The cleaning composition of the present invention is particularly advantageously used in combination with fluorine-containing solvents of the third generation.

The cleaning composition of the present invention comprises 1 to 90% by weight of a surfactant containing fluorine and 10 to 95% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent. Preferably, the cleaning composition comprises 5 to 70% by weight of a surfactant containing fluorine and 30 to 95% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent. When the content of the surfactant containing fluorine is less than 1% by weight, there is the possibility that the cleaning ability, the antistatic property and softness are not sufficiently exhibited. When the content of the surfactant containing fluorine exceeds 90% by weight, there is the possibility that viscosity, stability and easiness for use of the cleaning composition for dry cleaning are inferior.

In the cleaning composition for dry cleaning of the present invention, the surfactant containing fluorine is a salt of a phosphoric acid ester containing fluorine which is represented by general formula [1].

(1) A phosphoric acid ester of a polyoxyalkylenealkylsulfonamide ether containing fluorine which is represented by general formula [1]:

[1]



wherein  $\text{R}^1$  represents a perfluoroalkyl group having 3 to 12 carbon atoms, preferably 6 to 8 carbon atoms,  $\text{R}^2$  represents an alkyl group having 1 to 5 carbon atoms, preferably 1 to 3 carbon atoms,  $\text{R}^3$  represents an alkylene group having 2 to 4 carbon atoms, preferably 2 or 3 carbon atoms,  $q$  represents a number of 0 to 10, preferably 1 to 5, and  $r$  represents a number of 1 or 2, preferably 1.

In the cleaning composition for dry cleaning of the present invention, it is preferable that the salt of a phosphoric acid ester of a polyoxyalkylenealkylsulfonamide ether containing fluorine is a salt of said ester with an amine represented by general formula [2], [3], or [4] or an adduct of an alkylene oxide with said amine.

(2) An amine represented by general formula [2]:

[2]



wherein  $\text{R}^4$  and  $\text{R}^5$  each represents hydrogen atom, an alkyl group having 1 to 12 carbon atoms, cyclohexyl group, benzyl group or a hydroxylalkyl group having 1 to 4 carbon atoms, and  $\text{R}^4$  and  $\text{R}^5$  may be the same with or different from each other. In general formula [2], it is preferable that at least one of  $\text{R}^4$  and  $\text{R}^5$  represents an alkyl group having 1 to 10 carbon atoms, cyclohexyl group, benzyl group, or a hydroxylalkyl group having 2 or 3 carbon atoms.

(3) A diamine represented by general formula [3]:

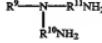
[3]



wherein  $\text{R}^6$  and  $\text{R}^7$  each represents hydrogen atom or an alkyl group having 1 to 6 carbon atoms,  $\text{R}^8$  and  $\text{R}^7$  may be the same with or different from each other, and  $\text{R}^8$  represents an alkylene group having 1 to 10 carbon atoms. In general formula [3], it is preferable that  $\text{R}^8$  and  $\text{R}^7$  each represents hydrogen atom or an alkyl group having 1 or 2 carbon atoms.

(4) A triamine represented by general formula [4]:

[4]



wherein  $\text{R}^9$  represents hydrogen atom or an alkyl group having 1 to 4 carbon atoms,  $\text{R}^{10}$  and  $\text{R}^{11}$  represents an alkylene group having 2 to 6 carbon atoms, and  $\text{R}^{10}$  and  $\text{R}^{11}$  may be the same with or different from each other. In general formula [4], it is preferable that  $\text{R}^9$  represents hydrogen atom or an alkyl group having 1 or 2 carbon atoms.

By the use of the surfactant containing fluorine which is the salt of the amine represented by general formula [2], [3], or [4] or an adduct of an alkylene oxide with the amine

with the phosphoric acid ester containing fluorine which is represented by general formula [1], the cleaning composition for dry cleaning exhibits an enhanced cleaning property and property for preventing soiling of cleaned articles and provides cleaned articles with an excellent antistatic property and softness. Moreover, solubility of the cleaning composition for dry cleaning into a solvent for dry cleaning can be increased.

In the cleaning composition for dry cleaning, it is preferable that the fluorohydrocarbon solvent is an alkoxyperfluoroalkane represented by general formula [5]:



[5]

wherein n represents a number of 3 or 4, and m represents a number of 1 to 3.

In the cleaning composition for dry cleaning of the present invention, it is preferable that the auxiliary solubilizing agent is an alcohol solvent such as methanol, ethanol and isopropanol, an ether solvent which is an adduct of an alkylene oxide with an alcohol, a glycol solvent, a hydrocarbon solvent, or a ketone solvent. The auxiliary solubilizing agent can be used singly or as a mixture of two or more agents. In the composition of the present invention, the cleaning composition for dry cleaning can have a decreased viscosity and an increased stability when the auxiliary solubilizing agent is comprised. Among the auxiliary solubilizing agents, 3-methyl-3-methoxybutanol which has a low toxicity and a relatively high flash point is preferably used.

In the cleaning composition for dry cleaning of the present invention, where necessary, nonionic surfactants, such as polyoxypropylene(7mol) perfluoroalkyl ether, polyoxyethylene(2 mol) nonylphenyl ether, polyoxyethylene(3 mol) lauryl ether, silicone oils and rust preventives may suitably be added.

To summarize the advantages obtained by the present invention, when dry cleaning is carried out using a solution obtained by adding the cleaning composition for dry cleaning of the present invention to an alkoxyperfluoroalkane, i.e., a so-called dry cleaning solvent of the third generation, the excellent cleaning property and the property of preventing soiling of cleaned articles can be obtained, and the cleaned article is provided with the antistatic property and softness.

## EXAMPLES

The present invention is described more specifically with reference to examples in the following. However, the present invention is not limited to the examples.

In the examples and the comparative examples, evaluation of the properties was conducted in accordance with the following methods.

### (1) Degree of Cleaning and Degree of Soiling of Cleaned Articles

In a 500 ml stainless pot, 0.3% by volume of a cleaning composition was dissolved into 100 ml of methyl perfluorobutyl ether (solvent 1) or ethyl perfluorobutyl ether (solvent 2) to prepare a cleaning liquid. White cloths of a No. 40 cotton broad cloth, a wool muslin, an acrylic knit fabric and a polyester jersey which had a dimension of 4 cm×8 cm and soiled cloths which were prepared from the white cloths in accordance with the method of Japanese Association of Oil Chemistry and had a dimension of 4 cm×8 cm were cleaned with the above cleaning liquid at 20° C. for 10 minutes using ROUNDA-O-METER (manufactured by TAIKEI KAGAKUSEIKI SEISAKUSHO Co., Ltd.; L-20). In

the method of Japanese Association of Oil Chemistry, cloths were treated by patting in a soiling bath prepared by dissolving 1 g of hardened beef tallow, 3 g of liquid paraffin and 0.5 g of carbon black in 800 g of carbon tetrachloride, and the reflectivity was adjusted to about 30%. The liquid was removed from the soiled cloths using a centrifugal dehydrator (manufactured by EIKO SANGYO Co., Ltd.; H120A) for 1 minute, and the obtained cloths were left standing for 60 minutes for drying. The reflectivity at 550 nm of the white cloths and the soiled cloths before and after the cleaning was measured using a calorimeter (manufactured by MURAKAMI SHIKISAIGIJUTU KENKYUSHO Co., Ltd.; CLEANMASTER CM-53D), and the degree of cleaning and the degree of soiling of cleaned articles were calculated in accordance with the following equations:

$$\text{degree of cleaning (\%)} = \frac{(S_1 - S_2) / (W_1 - W_2)}{100} \times 100$$

$$\text{degree of soiling of cleaned articles (\%)} = \frac{(W_1 - W_2) / W_1}{100} \times 100$$

wherein:

S<sub>1</sub>: the reflectivity of a soiled cloth before the cleaning

S<sub>2</sub>: the reflectivity of a soiled cloth after the cleaning

W<sub>1</sub>: the reflectivity of a white cloth before the soiling and the cleaning

W<sub>2</sub>: the reflectivity of a white cloth after the cleaning.

The cotton broad cloth, the wool muslin, the acrylic knit fabric and the polyester jersey are hereinafter abbreviated as cotton, wool, acrylic and polyester, respectively.

### (2) Antistatic property

A cleaning composition for dry cleaning in an amount of 0.2% by volume was dissolved into 10 liters of ethyl perfluorobutyl ether. Trousers for men (100% wool) and a skirt for women (100% polyester) which were soiled after use were cut into halves to prepare test cloths. The test cloths were cleaned with the above solution containing the cleaning composition using a dry cleaning tester (manufactured by TAIKEI KAGAKUSEIKI SEISAKUSHO Co., Ltd.; TESTER DC-2) at a room temperature for 15 minutes. The liquid was removed from the cleaned cloths using a centrifugal dehydrator for 1 minute. The test cloths were then dried in a drier with circulation of air heated at 50° C. for 10 minutes. The electric resistance at the surface of the test cloths was measured immediately after being taken out of the drier using an electric insulation-resistance tester (manufactured by TOA DENPA Co., Ltd.; SM-8210).

### (3) Softness

After the test cloths used for the evaluation of the antistatic property were left standing in a room, the softness was evaluated by the feel of touch and classified into the following five grades:

1: rough and hard

2: slightly hard

3: soft

4: considerably soft

5: very soft

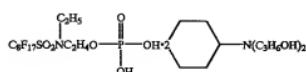
Softer the cloth, the less the formation of lines and the better the finishing and the feel in use.

### (4) Cleaning Property

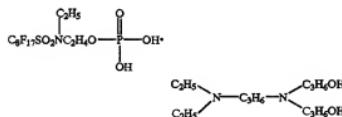
After being used for the evaluation of the softness, soiled portions of the test cloths and the original cloths were compared with each other by visual observation.

Chemical formulae of the compounds used in the Examples and Comparative Examples are as follows:

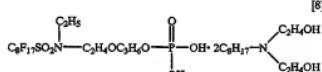
(1) Cyclohexyldipropanolamine salt of N-ethylperfluoroctylsulfonamidoethyl phosphate



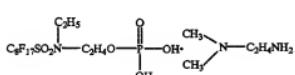
(2) N,N-diethyl-N',N'-dihydroxypropyl-1,3-propyldiamine salt of N-ethylperfluoroctylsulfonamidoethyl phosphate



(3) Octyldihydroxyethylamine salt of N-ethylperfluoroctylsulfonamidopropoxyethyl phosphate



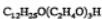
(4) N,N-dimethyl-1,2-ethanediamine salt of N-ethylperfluoroctylsulfonamidoethyl phosphate



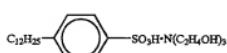
(5) Polyoxypropylene(7 mol) 2-perfluorobhexylethyl ether



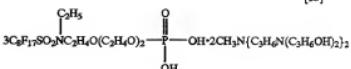
(6) Polyoxyethylene(3 mol) lauryl ether



(7) Triethanolamine salt of dodecylbenzenesulfonic acid



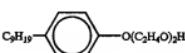
(8) Methylbis(dihydroxypropylaminomethyl)amine salt of N-ethylperfluoroctylsulfonamidoethoxyethoxyethyl phosphate



(9) Polyoxyethylene(2 mol) 2-ethylhexyl ether



(10) Polyoxyethylene(2 mol) nonylphenyl ether



#### Example 1

Cyclohexyldipropanolamine salt of N-ethylperfluoroctylsulfonamidoethyl phosphate expressed by formula [6] in an amount of 30 parts by weight, 20 parts by weight of 3-methyl-3-methoxybutanol and 50 parts by weight of ethyl perfluorobutyl ether were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 12% for cotton, 14% for wool, 7% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 3.8% for cotton, 4.8% for wool, 6.6% for acrylic and 9.0% for polyester.

When solvent 2 was used, the degree of cleaning was 15% for cotton, 24% for wool, 11% for acrylic and 11% for polyester. The degree of soiling of cleaned articles was 4.0% for cotton, 4.3% for wool, 9.8% for acrylic and 17.6% for polyester.

#### Example 2

N,N-diethyl-N',N'-dihydroxypropyl-1,3-propyldiamine salt of N-ethylperfluoroctylsulfonamidoethyl phosphate expressed by formula [7] in an amount of 10 parts by weight, 50 parts by weight of 3-methyl-3-methoxybutanol and 40 parts by weight of ethyl perfluorobutyl ether were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 12% for cotton, 12% for wool, 7% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 3.9% for cotton, 5% for wool, 8.1% for acrylic and 11.8% for polyester.

When solvent 2 was used, the degree of cleaning was 15% for cotton, 23% for wool, 10% for acrylic and 10% for polyester. The degree of soiling of cleaned articles was 4.7% for cotton, 5.1% for wool, 12.5% for acrylic and 18% for polyester.

## Example 3

Octylidihydroxyethylamine salt of N-ethylperfluorooctylsulfonamidoxyethyl phosphate expressed by formula [8] in an amount of 70 parts by weight and 30 parts by weight of 3-methyl-3-methoxybutanol were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 11% for cotton, 13% for wool, 7% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 3% for cotton, 4.8% for wool, 6.8% for acrylic and 9.5% for polyester.

When solvent 2 was used, the degree of cleaning was 14% for cotton, 23% for wool, 11% for acrylic and 11% for polyester. The degree of soiling of cleaned articles was 3.9% for cotton, 4.1% for wool, 11.2% for acrylic and 17.6% for polyester.

## Example 4

N,N-dimethyl-1,2-ethanediamine salt of N-ethylperfluorooctylsulfonamidoethyl phosphate expressed by formula [9] in an amount of 30 parts by weight, 40 parts by weight of 3-methyl-3-methoxybutanol, and 30 parts by weight of ethyl perfluorobutyl ether were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 12% for cotton, 12% for wool, 6% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 3.5% for cotton, 4.5% for wool, 8.2% for acrylic and 10.3% for polyester.

When solvent 2 was used, the degree of cleaning was 14% for cotton, 22% for wool, 9% for acrylic and 9% for polyester. The degree of soiling of cleaned articles was 4.5% for cotton, 4.3% for wool, 12.8% for acrylic and 18.7% for polyester.

## Comparative Example 1

Polyoxypropylene(7 mol) 2-perfluorobexyethyl ether expressed by formula [10] in an amount of 50 parts by weight and 50 parts by weight of 3-methyl-3-methoxybutanol were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 9% for cotton, 10% for wool, 4% for acrylic and 4% for polyester. The degree of soiling of cleaned articles was 6.2% for cotton, 6.3% for wool, 10.9% for acrylic and 17.3% for polyester.

When solvent 2 was used, the degree of cleaning was 12% for cotton, 20% for wool, 8% for acrylic and 8% for polyester. The degree of soiling of cleaned articles was 6.9% for cotton, 5.6% for wool, 17.1% for acrylic and 24.3% for polyester.

## Comparative Example 2

Polyoxyethylene(3 mol) lauryl ether expressed by formula [11] in an amount of 30 parts by weight and 70 parts

by weight of 3-methyl-3-methoxybutanol were mixed together to prepare a cleaning composition for dry cleaning, and the degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a cleaning liquid containing the prepared cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 8% for cotton, 10% for wool, 5% for acrylic and 5% for polyester. The degree of soiling of cleaned articles was 6.2% for cotton, 5.4% for wool, 10.7% for acrylic and 16.6% for polyester.

When solvent 2 was used, the degree of cleaning was 11% for cotton, 20% for wool, 7% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 7.5% for cotton, 6.0% for wool, 16.3% for acrylic and 23.5% for polyester.

## Comparative Example 3

Triethanolamine salt of dodecylbenzenesulfonic acid expressed by formula [12] in an amount of 20 parts by weight, 30 parts by weight of 3-methyl-3-methoxybutanol, and 50 parts by weight of ethyl perfluorobutyl ether were mixed together to prepare a cleaning composition for dry cleaning, and cleaning using a cleaning liquid containing the prepared cleaning composition and measurement of the degree of cleaning and the degree of soiling of cleaned articles were attempted.

However, the prepared cleaning composition for dry cleaning was insoluble in solvent 1 (methyl perfluorobutyl ether) and solvent 2 (ethyl perfluorobutyl ether). Therefore, the cleaning tests could not be made.

## Comparative Example 4

The degree of cleaning and the degree of soiling of cleaned articles were measured after cleaning using a solvent alone without adding a cleaning composition for dry cleaning.

When solvent 1 was used, the degree of cleaning was 8% for cotton, 9% for wool, 4% for acrylic and 4% for polyester. The degree of soiling of cleaned articles was 6.7% for cotton, 6.1% for wool, 12.5% for acrylic and 19.3% for polyester.

When solvent 2 was used, the degree of cleaning was 10% for cotton, 19% for wool, 7% for acrylic and 7% for polyester. The degree of soiling of cleaned articles was 7.1% for cotton, 6.8% for wool, 18.1% for acrylic and 25.6% for polyester.

The formulations of the cleaning compositions used in Examples 1 to 4 and Comparative Examples 1 to 3 are shown in Table 1. The results of the measurements of the degree of cleaning and the degree of soiling of cleaned articles are shown in Table 2.

TABLE 1

	Example				Comparative Example			
	1	2	3	4	1	2	3	
<u>Formulation (parts by weight)</u>								
<u>surfactant containing fluorine</u>								
65 compound of formula [6]	30	—	—	—	—	—	—	—
compound of formula [7]	—	10	—	—	—	—	—	—

TABLE 1-continued

	Example		Comparative Example				
	1	2	3	4	1	2	3
compound of formula [8]	—	—	70	—	—	—	—
compound of formula [9]	—	—	—	30	—	—	—
<u>surfactant</u>							
compound of formula [10]	—	—	—	—	50	—	—
compound of formula [11]	—	—	—	—	—	30	—
compound of formula [12]	—	—	—	—	—	—	20
auxiliary solubilizing agent	40	50	30	40	50	70	30
3-methyl-3-methoxybutanol							
fluorohydrocarbon solvent							
ethyl perfluorobutyl ether	30	40	—	30	—	—	50

Methylbis(dihydroxypropylaminopropyl)amine salt of 5 N-ethylperfluorooctylsulfonamidoethoxyethoxyethyl phosphate expressed by formula [13] in an amount of 30 parts by weight, 60 parts by weight of 3-methyl-3-methoxybutanol, and 10 parts by weight of isopropyl alcohol were mixed together to prepare a cleaning composition for dry cleaning.

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The antistatic property was evaluated using a cleaning liquid containing the prepared cleaning composition for dry cleaning, and the electric resistance was found to be  $4 \times 10^{12} \Omega$  with trousers and  $2 \times 10^{11} \Omega$  with a skirt. The softness was 15 4 with trousers and 4 with a skirt. Soils on the trousers and the skirt which were found before cleaning were almost completely removed by the cleaning.

TABLE 2

	Example				Comparative Example			
	1	2	3	4	1	2	3	4
<u>Solvent 1</u>								
<u>degree of cleaning (%)</u>								
cotton	11	12	11	12	9	8	—	8
wool	13	12	13	12	10	10	—	9
acrylic	6	7	7	6	4	5	—	4
polyester	8	7	7	7	4	5	—	4
degree of soiling of cleaned articles (%)								
cotton	4.1	3.9	3.0	3.5	6.2	6.2	—	6.7
wool	4.0	5.0	4.8	4.5	6.3	5.4	—	6.1
acrylic	7.3	8.1	6.8	8.2	10.9	10.7	—	12.5
polyester	12.2	11.8	9.5	10.3	17.3	16.6	—	19.3
<u>Solvent 2</u>								
<u>degree of cleaning (%)</u>								
cotton	14	15	14	14	12	11	—	10
wool	23	23	23	22	20	20	—	19
acrylic	10	10	11	9	8	7	—	7
polyester	11	10	11	9	8	7	—	7
degree of soiling of cleaned articles (%)								
cotton	5.4	4.7	3.9	4.5	6.9	7.5	—	7.1
wool	5.2	5.1	4.1	4.3	5.6	6.0	—	6.8
acrylic	10.7	12.5	11.2	12.8	17.1	16.3	—	25.6
polyester	15.3	18.0	17.6	18.7	24.3	23.5	—	25.6

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When the results obtained by using the same fiber material and the same solvent shown in Table 2 are compared, it is understood that, with respect to the degree of cleaning, the results obtained in Examples in which the cleaning composition for dry cleaning of the present invention were used were better by about 3% than the results obtained in Comparative Examples in which conventional cleaning compositions for dry cleaning were used. Thus, the cleaning composition for dry cleaning of the present invention has a superior cleaning property. It is also understood that, with respect to the degree of soiling of cleaned articles, the results obtained in Examples in which the cleaning composition for dry cleaning of the present invention were used were better by 1 to 8% than the results obtained in Comparative Examples in which conventional cleaning compositions for dry cleaning were used. Thus, the cleaning composition for dry cleaning of the present invention has a superior property for preventing soiling of cleaned articles.

## Comparative Example 5

Polyoxyethylene(2 mol) 2-ethylhexyl ether expressed by formula [14] in an amount of 15 parts by weight, 15 parts by weight of polyoxyethylene(2 mol) nonylphenyl ether expressed by formula [15], and 70 parts by weight of isopropyl alcohol were mixed together to prepare a cleaning composition for dry cleaning.

The antistatic property was evaluated using a cleaning liquid containing the prepared cleaning composition for dry cleaning, and the electric resistance was found to be  $2 \times 10^{13} \Omega$  with trousers and  $10^{14} \Omega$  or more with a skirt. The softness was 60 3 with trousers and 3 with a skirt. Soils on the trousers and the skirt which were found before cleaning mostly remained after the cleaning.

The results obtained in Example 5 and Comparative Example 5 are shown in Table 3.

TABLE 3

	Example 5	Comparative Example 5
<u>Antistatic property (electric resistance, <math>\Omega</math>)</u>		
trousers	$4 \times 10^{12}$	$2 \times 10^{13}$
skirt	$2 \times 10^{11}$	$>10^{14}$
Softness		
trousers	4	3
skirt	4	3
<u>Cleaning property</u>		
trousers	soils almost completely removed	most of soils remained
skirt	soils almost completely removed	most of soils remained

When the cleaning composition for dry cleaning used in Example 5 which contained a salt of a propylene oxide adduct to a triamine represented by general formula [4] with an N-alkylperfluoroalkylsulfonamidoalkylpolyoxalkylene phosphatate represented by general formula [1] was dissolved into ethyl perfluorobutyl ether used as the solvent in an amount of 0.2% by volume and the obtained solution was used for dry cleaning, the cleaned trousers and skirt showed an excellent antistatic property, softness and cleaning property.

In contrast, when the hydrocarbon cleaning composition used in Comparative Example 5 was dissolved into ethyl perfluorobutyl ether used as the solvent in an amount of 0.2% by volume and the obtained solution was used for dry cleaning, the cleaned trousers and skirt showed an inferior antistatic property and harder feel of touch. This solution showed an inferior cleaning property.

What is claimed is:

1. A process for dry cleaning fabric, said process comprising the step of cleaning fabric by applying an effective amount of a cleaning composition for dry cleaning which comprises 1 to 90% by weight of a surfactant containing fluorine and 10 to 99% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent, wherein the surfactant containing fluorine is a salt of a phosphoric acid ester of a polyoxalkylenealkylsulfonamide ether containing fluorine which is represented by general formula (1):



wherein  $R^1$  represents a perfluoroalkyl group having 3 to 12 carbon atoms,  $R^2$  represents an alkyl group having 1 to 5 carbon atoms,  $R^3$  represents an alkylene group having 2 to 4 carbon atoms,  $q$  represents a number of 0 to 10, and  $r$  represents a number of 1 or 2, wherein said step of cleaning with a composition which includes the fluorohydrocarbon solvent includes the further step of providing an alkoxyperfluoroalkane represented by general formula (5):



wherein  $n$  represents a number of 3 or 4, and  $m$  represents a number of 1 to 3.

2. A process according to claim 1, wherein said step of cleaning with a composition which includes the auxiliary solubilizing agent includes the further step of providing a solvent or a mixture of solvents selected from the group consisting of alcohol solvents, ether solvents which are adducts of alkylene oxides with alcohols, glycol solvents, hydrocarbon solvents and ketone solvents.

3. A process for dry cleaning fabric, said process comprising the step of cleaning fabric by applying an effective amount of a cleaning composition for dry cleaning which comprises 1 to 90% by weight of a surfactant containing fluorine and 10 to 99% by weight of a fluorohydrocarbon solvent and/or an auxiliary solubilizing agent, wherein the surfactant containing fluorine is a salt of a phosphoric acid ester of a polyoxalkylenealkylsulfonamide ether containing fluorine which is represented by general formula (1):



wherein  $R^1$  represents a perfluoroalkyl group having 3 to 12 carbon atoms,  $R^2$  represents an alkyl group having 1 to 5 carbon atoms,  $R^3$  represents an alkylene group having 2 to 4 carbon atoms,  $q$  represents a number of 0 to 10, and  $r$  represents a number of 1 or 2,

wherein said step of cleaning with a composition which includes the salt of a phosphoric acid ester of polyoxalkylenealkylsulfonamide ether containing fluorine includes the further step of providing a salt of said ester with a first compound represented by general formula (2):



wherein  $R^4$  and  $R^5$  each represents a hydrogen atom, an alkyl group having 1 to 12 carbon atoms, cyclohexyl group, benzyl group or a hydroxylalkyl group having 1 to 4 carbon atoms, and  $R^4$  and  $R^5$  being the same or different from each other;

a diamine represented by general formula (3):



wherein  $R^6$  and  $R^7$  each represents a hydrogen atom or an alkyl group having 1 to 6 carbon atoms,  $R^6$  and  $R^7$  being the same with or different from each other, and  $R^8$  represents an alkylene group having 1 to 10 carbon atoms; a triamine represented by general formula (4):



wherein  $R^9$  represents a hydrogen atom or an alkyl group having 1 to 4 carbon atoms,  $R^{10}$  and  $R^{11}$  each represents an alkylene group having 2 to 6 carbon atoms, and  $R^{10}$  and  $R^{11}$  being the same or different from each other; or

an adduct of an alkylene oxide with the first compound, the diamine, or the triamine,  
 wherein said step of cleaning with a composition which includes the fluorohydrocarbon solvent includes the further step of providing an alkoxyperfluoroalkane represented by general formula (5):



(5)

wherein  $n$  represents a number of 3 or 4, and  $m$  represents a number of 1 to 3.

4. A process according to claim 3, wherein said step of cleaning with a composition which includes the auxiliary solubilizing agent includes the further step of providing a solvent or a mixture of solvents selected from the group consisting of alcohol solvents, ether solvents which are adducts of alkylene oxides with alcohols, glycol solvents, hydrocarbon solvents and ketone solvents.

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